DOCUMENT RESUME

ED 312 468 CE 053 584

TITLE	Transportation Education and Training. Meeting the Challenge. Proceedings of the Conference on Surface Transportation Education and Training (Williamsburg, Virginia, October 28-31, 1984). Special Report 210.
INSTITUTION	National Academy of Sciences - National Research Council, Washington, D.C. Transportation Research Board.
SPONS AGENCY	Federal Highway Administration (DOT), Washington, D.C. Bureau of Public Roads.; Urban Mass Transportation Administration (DOT), Washington, D.C.
REPORT NO	ISBN-0-309-03914-2
PUB DATE	85
NOTE	210p.
PUB TYPE	Collected Works - Conference Proceedings (021) -- Reports - Research/Technical (143) -- Reports - Descriptive (141)
EDRS PRICE	MF01/PC09 Plus Postage.
DESCRIPTORS	Career Choice; Educational Improvement; Educational Needs; Educational Planning; *Educational Trends; *Employment Opportunities; *Engineers; Futures (of Society); *Highway Engineering Aides; *Job Training; Motor Vehicles; Occupational Information; Postsecondary Education; Public Facilities; Road Construction; Traffic Control; *Transportation; Travel; Vehicular Traffic

ABSTRACT

This report contains the findings of a conference held to define the skills and educational background needed by new transportation professionals at all levels, to review the education and training currently being offered in this field, and to recommend other concepts and actions that will enhance transportation education and training. The proceedings are organized in three parts. Part 1 introduces the conference and contains the following: "Summary and Recommendations"; "Transportation Education and Meeting the Challenge" (Richard S. Page); and "Future Demand for Transportation Professionals" (Damian J. Kulash and William A. Hyman). Part 2 features the following workshop reports: "Transportation Engineers for Local, State, and Federal Government"; "Transportation Planners and Demand by Government Agencies and Their Consultants"; "Operations and Management Personnel for Transit Companies"; "Transportation Technicians: Who Are They and What Are Their Training Requirements?"; and "Carrier Management and Physical Distribution Personnel." Part 3 contains these 14 resource papers, each presented as a focus of discussion: "Demand for Transportation Education" (Louis J. Pignataro); "Transportation Education" (Michael D. Meyer); "Educating Tomorrow's Transportation Engineers" (Thomas D. Larson and Harvey Haack); "Training Requirements for Transportation Technicians and Technologists" (Donald L. Woods, A. Nelson Evans, Charley V. Wootan); "Education Requirements for Transportation Consultants" (Wilbur S. Smith); "What Are Shippers and Carriers Looking For?" (Gayton E. Germane); "Training Requirements for Transportation Operations Personnel" (James E. Reading, Barbara A. England, James W. Strecker); "Supplying Transportation Education" (Lester A. Hoel); "Transportation Education: University Degree Programs" (Edward Beimborn); "Transportation Education: Technical Training and Continuing Education" (David J. Cyra); "Efficient Utilization of Transportation Research and Educational Resources" (William M. Spreitzer); "Transportation Research and Its Link to Education" (Robert E. Paaswell); "Education and Training Needs of Women in Transportation" (Lillian C. Liburdi); and "Transportation Careers for Minorities" (Katie G. Dorsett and Julian M. Benjamin). (KC)

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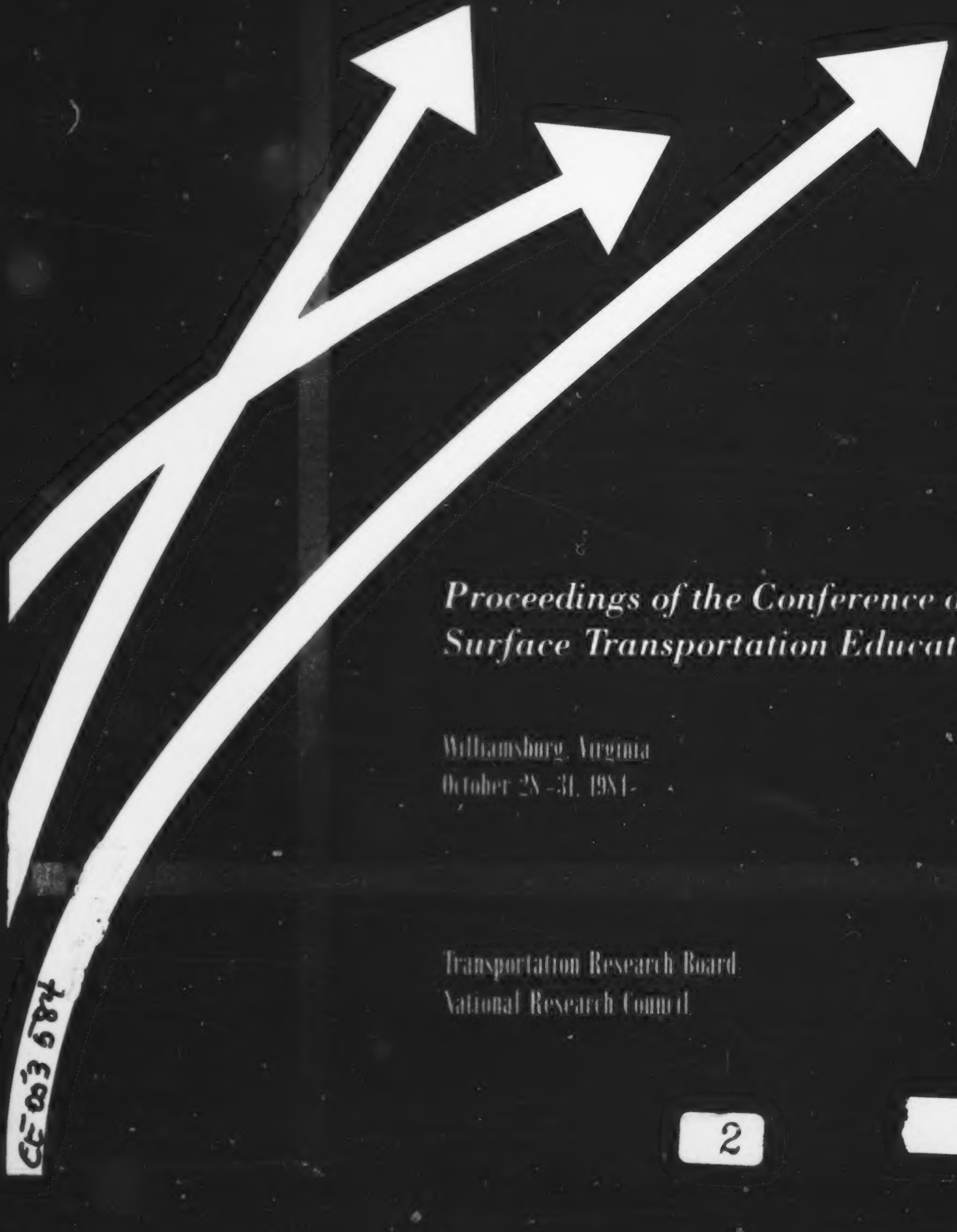
Special Report 210

TRANSPORTATION EDUCATION AND TRAINING
Meeting the Challenge



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Proceedings of the Conference on
Surface Transportation Education and Training

Williamsburg, Virginia
October 28–31, 1984

Transportation Research Board
National Research Council

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Special Report 210

TRANSPORTATION EDUCATION AND TRAINING
Meeting the Challenge

Proceedings of the Conference on Surface Transportation Education and Training

conducted by the
Transportation Research Board

sponsored by the
Urban Mass Transportation Administration
Federal Highway Administration
U.S. Department of Transportation

Williamsburg, Virginia
October 28-31, 1984

Transportation Research Board
National Research Council
Washington, D.C. 1985

Transportation Research Board Special Report 210
Price $16.00
Editor: Edythe Traylor Crump
Compositor: Harlow A. Bickford

modes
1 highway transportation
2 public transit

subject areas
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12 planning

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Printed in the United States of America

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The project that is the subject of this publication was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the publication were chosen for their special competence and with regard for appropriate balance.

The views expressed are those of the authors and do not necessarily reflect the views of the committee, the Transportation Research Board, the National Research Council, or the sponsors of the project.

Library of Congress Cataloging in Publication Data
National Research Council. Transportation Research Board.

Conference on Surface Transportation Education
and Training (1984 : Williamsburg, Va.)
Transportation Education: Meeting the Challenge,
Williamsburg, Virginia, October 28-31, 1984.

(Special report ; 210)
Sponsored by the Transportation Research Board,
Committee on Transportation Education and Training.
1. Transportation–Study and teaching–United
States–Congresses. 2. Transportation engineering–
Study and teaching–United States–Congresses.
I. National Research Council (U.S.). Transportation
Research Board. Committee on Transportation Education
and Training. II. Title. III. Series: Special report
(National Research Council (U.S.). Transportation
Research Board) ; 210.
HE192.U5C66 1984 388'.07'073 85-25920
ISBN 0-309-03914-2 ISSN 0360-859X

Sponsorship of Transportation Research Board Special Report 210

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Foreword

The current decade is bringing new challenges to the transportation profession. Significant maintenance and rehabilitation needs of the transportation system have resulted in increased demands on transportation agencies. These demands have occurred at a time when, in many transportation agencies, a large segment of the professional staff is close to retirement or is not trained in the requirements of the new program focus. At the same time, the microcomputer revolution requires a new type of transportation professional, an individual well versed in computer applications and able to work in a rapidly changing environment.

The Transportation Research Board Committee on Transportation Education and Training views these challenges as possibly resulting in unprecedented changes to the transportation profession. To fully explore the dimensions of these challenges, the committee organized a special conference on the needs and opportunities that face transportation education and training. The conference was held October 28-31, 1984, in Williamsburg, Virginia. The objectives of the conference were to

1. Define the skills and educational backgrounds needed by new transportation professionals at all levels to meet the challenges they will likely face during their careers. These challenges were to be viewed from the perspectives of transportation system employers, educators, and users.
2. Review the education and training currently being offered by academic institutions, technical schools, continuing education programs, and in-house training programs, and assess their capability to meet evolving needs and propose changes required in these programs to meet evolving needs.
3. Recommend other concepts and actions that will enhance the continuing contributions of transportation education and training to the profession and to improvements in transportation.

For 3 days conference participants deliberated on the major education and training issues facing the transportation profession. The first half of the conference focused on the numbers and types of transportation professionals desired by industry and government. Conference participants were assigned to one of five workshops in which the demand for transportation engineers, planners, transit operations personnel, technicians, and analysts for private sector firms was examined. After discussion of the demand characteristics for each type of transportation professional, the second half of the conference was devoted to an examination of the challenges faced by universities and training programs in supplying these types of transportation professionals. Special attention was given to the role of research, the development of curricula, and the importance of attracting women and minorities to the profession.

This report contains the findings of this conference and the resource papers produced to stimulate discussion among conference participants. The general conclusion reached at the conference is that the transportation profession faces serious human resource challenges as well as tremendous opportunities over the next 10 years. Recent attention to the needs of the highway and transit industry has spawned several proposals for funding multiyear research programs that will result in improved materials, procedures, analysis techniques, and organizational structures. However, it is important to remember that the human resource is the most critical component of an organization's ability to accomplish its goals. Only skilled and motivated transportation professionals can lead the industry into the 21st century.

The findings and recommendations of this conference must not be allowed to lie fallow. Specific action plans to implement conference recommendations should be adopted and monitored. This effort should involve numerous organizations, including the Transportation Research Board, American Association of State Highway and Transportation Officials, American Public Transit Association, U.S. Department of Transportation, National Science Foundation, state transportation agencies, professional societies, universities, and the private sector. Specific subgroups such as those covered in the workshops, rather than the profession as a whole, should be the focus of these follow-up activities. If all do their parts, the significant challenges facing transportation education and training can be converted into opportunities for constructive change.

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Part I Introduction

Summary and Recommendations

The Conference on Surface Transportation Education and Training was held in Williamsburg, Virginia, on October 28-31, 1984. The conference was sponsored by the Transportation Research Board, the Urban Mass Transportation Administration, and the Federal Highway Administration. There were approximately 80 participants, drawn from universities, government agencies, transit operators, consulting firms, transportation companies, and business firms.

The conference had three objectives:

1. To define the educational requirements of transportation professionals who will be entering or continuing practice during the next several decades;
2. To assess the ability of existing education and training programs to fulfill these educational requirements; and
3. To recommend measures to improve the ability of educators and employers to develop and effectively utilize human resources.

The findings and conclusions from the conference follow. These findings and conclusions are drawn primarily from the conference workshop discussions, as reflected in the reports prepared by the respective workshop chairpersons supplemented by observations made in the keynote paper and resource papers prepared for the conference. They also reflect the general discussion that occurred at the conference and the deliberations of the conference participants.

SENSE OF THE CONFERENCE

An overall sense of the attitudes and perceptions of the conference participants is captured in the following six words and phrases that appear repeatedly in the resource papers and workshop discussions.

1. Challenge. The transportation profession faces significant challenges that will tax the technical and managerial abilities of everyone involved. Although transportation education faces serious problems, these challenges should be viewed as a significant opportunity to define new directions for program development.
2. Change. Transportation professionals will face more change in the next 20 years than that which has occurred during the past 20 years. This rapidity of change is a major source of the new challenges facing the profession.
3. Image. The past image of the transportation profession and an incorrect perception of its future is inhibiting the ability of the profession to attract the best and most creative students and new graduates. Rectifying this image is perhaps the major challenge facing the profession today.

4. System Management. Tomorrow's transportation professionals will be concerned more with managing and maintaining existing systems than with developing new systems. This new orientation requires a change in the skills of transportation professionals.

5. Computers. The transportation professional needs the ability to apply current and emerging computer technology to problem solving and transportation management. This skill should go beyond mere computer literacy.

6. Communications. The transportation professional must have the ability to communicate effectively with the public, with other transportation professionals, with professionals in other fields, and with elected government officials.

CENTRAL FINDING: SOME AGGRESSIVE IMAGE BUILDING IS NEEDED

The challenges and opportunities facing the transportation professional are some of the most interesting and potentially rewarding that have ever occurred in the history of the profession. However, this is generally not recognized by students, advisors, and the public at large. The high-quality professionals needed to respond to these challenges will not be available unless this message is communicated in an effective manner. This can be done by developing and disseminating information on who transportation professionals are, what they do, and the leverage that they exert on the economy and society. Developing this type of information in an attractive format might well require the efforts of a consortium of professional societies and other interested parties.

SHORTAGES ARE EXPECTED

Although virtually all areas of transportation practice are currently able to hire well-qualified professionals when needed, there will be a much tighter market for these professionals in coming years. Agencies should act now to ensure that they have professionals with the new skills needed to respond to emerging requirements.

Transportation Engineers

The number of transportation engineers required in the future will increase, even though enrollments in transportation engineering curricula have been declining sharply, and a significant and sustained halt in this decline has yet to appear. As a result, the pipeline of future professionals, especially with advanced degrees, is rapidly emptying. Ultimately, this will divert educational resources away from transportation, which will limit the ability of educational institutions to respond to future shortages.

Transportation Planners

There is presently no significant shortage of transportation planners because demand and supply are both low. In addition, the number of traditional planning positions in public agencies may continue to decline. However, this situation could change rapidly in the future when it becomes more apparent that planning skills can be applied successfully to system maintenance and rehabilitation programs. The demand for planners might also increase at state and local government levels and in consulting firms as planning responsibilities are shifted away from the federal government. If anything, the educational pipeline is even emptier of planners than of engineers. Planning requirements in areas such as the environment and energy are likely to assume renewed importance in the future. As is the case in engineering, the empty pipeline will limit the ability of educational institutions to respond to these potential shortages.

Public Transit

Few qualified graduates are presently electing careers in public transit because of the stultified image of this area of practice. Consequently, qualified managers who will have the talents necessary to respond to the changing future role of public transit will be in short supply. More so than in almost any other area, the shortage in transit is one of quality rather than quantity. The entrepreneurial and communications skills required to manage a transit organization successfully today are in short supply and are being bid away from the public sector.

Transportation Technicians

The role of the transportation technician is changing and expanding, but it is not entirely clear how the demand for technicians will react to current trends. New technology is increasing productivity and reducing demand, but is also creating new jobs for the technicians who supply and service the new technology. Also, responsibilities traditionally reserved for entry-level engineers and other professionals are being shifted to technicians. It is likely that more and better qualified technicians will be needed.

Shippers and Carriers

There are expanding opportunities and exciting new challenges in freight transportation. Consequently, the private sector is attracting transportation-oriented students who historically might have elected public sector careers. Transportation and physical distribution management are also attracting increasing numbers of women and minorities. These trends are beneficial to commercial transportation, but will serve to exacerbate the other shortages mentioned earlier.

INSTITUTIONAL BARRIERS

There are a number of societal and institutional barriers to the recruitment, development, and effective utilization of human resources in transportation.

Salary Structure

The salaries of professionals employed in transportation, especially engineers, are currently well below those that graduates can obtain in other fields. Public sector agencies need to recognize this and take corrective measures if they expect to attract qualified graduates.

Diminishing Public Service Ethic

Public sector salaries, especially in state and local government and in transit agencies, have always lagged behind salaries for comparable private sector work. However, this salary gap was historically counteracted somewhat by the recognition that public sector work was a service to society and provided valuable professional experience. This public service ethic appears to be lacking in today's graduates. Institutions must work to rekindle this ethic, in addition to signaling the importance of this type of work through improved salaries.

Rigid Hiring and Promotion Practices

The hiring and promotion practices of public sector transportation agencies were developed in an era when both jobs and candidates were plentiful and when design and construction of new facilities were the agencies' primary activities. This situation has changed drastically, but these personnel practices have not changed. In particular, many positions that currently have little or no engineering content and that require considerable managerial skill are still reserved for engineers.

Underutilization of Women and Minorities

Although women and minorities are underrepresented in virtually all professional areas, this is especially evident in transportation. The rigid hiring and promotion policies identified previously are major reasons for this. There has also been a lack (until recently) of appropriate programs at historically black universities and colleges. Educational institutions and employers must recognize that the challenges facing the transportation profession require effective utilization of all of the available human resources.

Undervalued Professional Development

Employing organizations, especially in the public sector, have a direct interest in the educational development of their employees. Organizations should encourage and support employee efforts to obtain additional training or advanced degrees. Increased attention should be given to improved professional development if employers are to be successful in ensuring that their professionals acquire the new skills that will be needed to face future challenges.

SIGNIFICANT TRENDS

A number of significant trends are driving the emerging educational needs of future transportation professionals.

1. Development to Management. Future professionals will be involved in broader roles than their predecessors. This will be characterized by involvement in management, maintenance, rehabilitation, and improvement of existing transportation systems rather than solely or principally in the development of new systems.
2. Privatization. Government is currently looking to the private sector to provide an increasing proportion of the goods and services required by society. This includes the use of contractors and consultants to perform services formerly performed internally. This also implies competition with the private sector for the best people.
3. Computerization. Computer technology is becoming a way of life in all organizations. This includes increasing use of computer-aided design and manufacturing, microcomputers, distributed processing, and office automation.
4. Reorganization. Transportation agencies are being restructured at the federal, state, and local levels to respond to emerging needs. This institutional change is requiring increased coordination and communication between transportation professionals. Significant restructuring also is occurring in the private sector.
5. Deregulation. Decreased government oversight of both passenger and freight transportation services is reducing the need for transportation professionals in some areas and redefining the skills needed by transportation professionals in other areas.
6. Internationalism. Transportation professionals in all areas increasingly need a global perspective and an understanding of international trends and events to discharge their responsibilities effectively.

EDUCATIONAL NEEDS

Transportation professionals require education and training in the eight general areas identified below to effectively meet tomorrow's challenges. To the extent that existing educational programs fail to meet these needs, transportation agencies will face a shortage of graduates with the requisite skills.

1. Broad-based education. The transportation professional must have the flexibility to adapt to new and changing circumstances. This can be fostered through exposure to a broad curriculum with strong emphasis on the fundamentals.
2. Communications skills. Excellent writing and speaking skills are required for the professional to communicate problem definitions and solutions and to foster implementation of those solutions.
3. Computer skills. The professional should be comfortable with the application of computer technology to transportation problem solving.
4. Analytical skills. Transportation programs have traditionally emphasized development of skills in technical analysis. This traditional emphasis is still needed, but the transportation professional also needs to be proficient in areas such as economics, statistics, finance, marketing, and cost analysis.
5. Strategic thinking. This set of skills might also be defined as problem solving, or an implementation orientation. In other words, the professional must be able to identify the correct problem, define it properly, and develop solutions that are sensitive to timing, politics, and other realities of implementation.

6. Entrepreneurship. The transportation professional should cultivate the ability to identify opportunities and create organizations and mechanisms for seizing those opportunities and developing effective programs and projects.

7. Group dynamics. The professional should be knowledgeable of organizational behavior and the dynamics of groups of all sizes and at all levels. The professional needs to have the interpersonal skills required for consensus building and similar activities required to solve challenging and complex problems.

8. Global perspective. Increasingly, transportation problems and solutions transcend national boundaries. The transportation professional should be sensitive to and aware of global trends and the international implications of transportation decisions.

In summary, there is a dynamic tension between the transportation professional's needs for a broad education and an education that is also highly specialized. Developing the education and training programs to meet these needs will require the best efforts of transportation educators. Attracting and motivating the new graduates who have these skills and providing them with rewarding career paths provide clear challenges to the employers of transportation professionals.

EDUCATIONAL PROGRAMS

No single type of program can provide all of the education and training needed by tomorrow's transportation professionals. Meeting these requirements will require utilization of all available forms of education and training, including

1. Degree programs at colleges and universities;
2. Certificate programs at 2- and 4-year colleges and vocational-technical institutes;
3. Continuing education programs, including short courses, workshops, and seminars offered by educational institutions, training institutes, equipment vendors, and other qualified providers;
4. Professional society meetings and activities;
5. In-house training courses developed and offered by employers; and
6. On-the-job training.

Significantly, the last four of these six types of educational opportunities are programs that can be fostered and promoted by agency and company management without extensive reliance on educational institutions.

EDUCATIONAL BARRIERS

The conference participants pointed to several problems believed to be particularly significant as potential barriers to meeting future educational needs.

1. Declining enrollments. Reduced enrollments in transportation programs signal to academic administrators that there is no need to devote significant resources to transportation. In addition, there are few problems in transportation education and training that could not be helped by a sustained increase in student enrollment.

2. Rigid curricula. Transportation programs exist primarily in schools of engineering and business and must meet the stringent accreditation criteria applied to these broader disciplines. This greatly constrains the ability of transportation educators to modify curricula to meet future needs.

3. Outdated and unresponsive curricula. Most current transportation curricula were developed to respond to educational needs identified 10 to 20 years ago. Curricula have not been updated to respond to today's educational requirements.

4. Deteriorating facilities. Transportation is a specialized technical pursuit, and practice in the field has evolved to take advantage of emerging technologies. As in other technical fields, educational institutions have not been able to keep up with industry and government in acquiring the latest technology. Also, the overall educational infrastructure is deteriorating and requires major refurbishing.

RECOMMENDATIONS

No single concise set of recommendations can cover all the diverse needs and problems in transportation education and training. By following a few general recommendations, outlined in the following sections, the transportation profession would do much to meet some of the major challenges.

Get the Word Out

The challenges and opportunities in transportation are largely unrecognized outside of the profession. The nature of these challenges and the rewards of working on them must be communicated to prospective students and to those in a position to influence career choices. Accomplishing this will require the combined efforts of professional societies, universities, and employers, including government.

Adapt Traditional Skills to New Challenges

Problems of management, maintenance, and rehabilitation of transportation systems can be addressed successfully by the graduates of traditional transportation programs in engineering, business, and planning. New challenges do not require a totally new set of professionals but rather a reorientation, and perhaps some retraining, of current professionals. Implementing this concept may require transportation agency management to reconsider current job descriptions and activity assignments.

Review and Revise Transportation Curricula

The finding that many existing programs are outdated and unresponsive implies that the ongoing process of program review and revision needs to be accelerated. This will enable program graduates to contribute significantly to solving today's problems, thereby enhancing the demand for additional graduates.

Encourage Programs for Women and Minorities

Programs that have been developed to increase the participation of women and minorities in the transportation profession should be continued and enhanced.

This should include support for programs at both minority and mainstream institutions.

Increase Interaction Between Educational Programs and Government and Industry

Such interaction will greatly increase the relevance of transportation education and training and will promote recognition by government and industry that education and training can make a real contribution toward meeting their needs. A tremendous variety of beneficial interaction mechanisms are available.

Reward Employee Professional Development

The ever-changing nature of the challenges in transportation requires a lifelong commitment to learning. Employees who make that commitment should be rewarded for the value of the contributions that they make. Transportation agencies should also consciously maintain an environment in which employee initiative is encouraged and rewarded.

Preserve Strong University Research

Although training offers significant opportunities for transportation agencies to meet their professional needs, the nation's universities and colleges will continue to be the supplier of new professionals to the transportation industry. However, serious problems often hamper, and in the future could impair, the ability of educational institutions to produce these professionals. Declining enrollments in transportation-related programs have created a significant shift in university resources away from these programs to the more popular programs, usually computer science and electrical engineering. Outdated facilities and equipment are, in some cases, providing students with an education that is no longer relevant to professional practice. And perhaps most important, as research funds in the public sector become more scarce, universities will be unable to support faculty and students or will turn to private-sector sources, which will change the focus and subsequent job interest of new transportation professionals. It appears clear that for the future viability of public-sector transportation, it is essential that sufficient research opportunities exist not only to advance the status of knowledge in transportation but also to educate future transportation professionals, who are central to the economic well-being of the nation.

Transportation Education and Meeting the Challenge

Richard S. Page

This conference convenes at a critical time for the surface transportation industry. A series of factors are converging to shape what could be a looming crisis for universities and employers alike, or an opportunity of equally great potential.

The convening of this conference, bringing together transportation officials and practitioners, consultants, and educators in the first serious look at the dimensions and ramifications of the subject, may itself be one small but significant step toward seizing the opportunity. John Gardner reminds us that great opportunities come disguised as insoluble problems, and the familiar Chinese proverb states, "A journey of a thousand miles begins with a single step." This conference can constitute that beginning step.

Tonight I want to set the stage for the deliberations of this conference by describing the environment of the recent past and contrasting it with the environment of the near future. I will also try to characterize the kind of transportation professional, and the kind of transportation education, that will be needed in the future. Finally, I will suggest a modest proposal for future research and action.

First, the problem: the biggest challenge in surface transportation is the rebuilding of our infrastructure and its expansion to serve future growth. We must also produce a new generation of professionals to replace the post-war generation that is retiring--professionals equipped to design and manage the rebuilding. A third dimension of the problem is that the requirements for the future professional, the environment in which he or she works, will be different in the future, making it hard to determine which education and training programs are best. The problem is sorely aggravated by two other important facets: the shortage of funds for research and the relatively small and diverse scale of education for the transportation industry.

No wonder this conference is timely and needed: we are looking at an industry on the threshold of its biggest days, shaped by new technology and unfamiliar forces, staffed by a mix of near-retirees and relatively untrained and inexperienced successors, supported by a university base desperately short of money, and often out of touch with the industry. Given this characterization, we might wonder whether we are courageous enough, or foolish enough, to stay and discuss meeting the transportation education challenge.

I urge you to face the challenge squarely--and I offer you some encouragement in the knowledge that outside the transportation industry, we are not alone. Let me quickly remind you of some developments outside the transportation industry that serve to illuminate our problems and show us that other sectors have similar difficulties.

In education, we have been told repeatedly in a barrage of studies that our public schools badly need reform. A "rising tide of mediocrity" threatens our republic; "a place called school" is boring; untrained and poorly paid teachers populate our classrooms; large numbers of at-risk children have no preschool or kindergarten; 25 percent of high school age children drop out and do not graduate from high school; and reform and renewal are extremely hard to achieve in such a large, diverse, decentralized and fragmented industry.

Now a new report informs us that quality in our colleges and universities is slipping badly. Graduate record exam scores have declined over the past two decades, especially in subjects that require high verbal skills; students are majoring in increasingly narrow specialities; faculty are not paid well and have lost space, equipment, and staff; and the physical plant is deteriorating.

Another study informs us, in words that fit the transportation industry, that university presidents are quitting faster and are harder to replace. The common problem appears to be growing responsibility without any commensurate increase, perhaps even decreases, in authority. Clark Kerr headed a commission for the Association of Governing Boards of Universities and Colleges that reported that average tenure for a university president has declined from 11 years in 1960 to 7 years today (that is still higher than urban transit general managers). The commission found that one-half of the number 2 and number 3 people do not want the top job.

Many of you are affiliated with universities and colleges and may have opinions about these trends as well as how they affect the transportation industry. Certainly, they paint a gloomy picture in my mind. Recently, a friend involved in the search for a major transit general manager post remarked to me: "There's not much seasoned talent out there. . . ." When I quote a recent newspaper article stating "there is really a terrific shortage of talent for serious jobs," you might think it related to transportation but the field being described is retailing. The article continues, "We're beginning to see another round of movement at the top in retailing with significant earnings being offered." The movement is a source of concern--but at least retailing offers significant earnings.

In the paper, "Transportation Education--University Degree Programs," elsewhere in this report, Beimborn reminds us that it is only 16 years to the 21st century. College freshmen today in the class of 1988 will spend most of their working lives in the first third of that new era. Before we try to imagine what the transportation industry will be like and what education and training will be needed, I invite you to look back 16 years to the year 1968.

Most of us in this room can remember the primary characteristics of the transportation industry environment:

- Engineers were in their heyday;
- The Interstate system was under full-scale construction except in cities where the freeway revolt had occurred;
- Transit was still almost entirely provided by private companies, and the few public agencies were monopolies;
- Bay Area Rapid Transit (BART) had not opened;
- Conrail and Amtrak did not exist;
- The Urban Mass Transportation Administration (UMTA) was created in July 1968 but offered only a small capital, planning, and research budget;
- There were but a few transportation centers or education programs;
- The emphasis was on new construction and expansion;

- Transportation decisions were still largely private and were not yet the subject of much political, public, and media attention, with few exceptions;
- Surface transportation was heavily regulated at the state and federal levels;
- The environmental impact assessment (EIS) was not even a gleam in the Sierra Club's eye;
- The energy crisis simply had not occurred; gasoline sold at 35 cents a gallon; and
- The computer was hardly a household word, and its use was just beginning in the public sector.

Stop and think for a moment--just 16 years ago we were pre-computer, pre-energy crisis, pre-EIS, virtually pre-UMTA, pre-public transit management. In fact, looking back, we were "pre-worry" compared to life as we know it now.

These and other changes have transformed the transportation industry. And I have not even mentioned social changes such as the civil rights movement, the women's movement, the desire for personal growth, more single-parent families, and other changes.

The professionals who dominated the transportation industry had the same skills, professional training, and often the same orientation as their immediate predecessors. The traditional academic disciplines, especially engineering, predominated. Few people transferred into highway agencies or transit companies at high levels. Transit companies relied heavily on veterans who came up through the ranks of operations and maintenance, plus finance people who had to cut costs and try to find a profit.

What are some of the trends or forces or environmental determinants shaping the industry today? What kind of world will it be 16 years from now, or 36 years from now? What changes are coming, that we cannot possibly foresee, of the magnitude of those that have transformed our industry since 1968?

I cannot answer those questions. What I can offer are a few factors already visible that continue to alter and transform the nature of the transportation industry. One is the computer--once applied primarily to financial transactions, but now useful for transit scheduling, for parts inventories, for computer-aided design, for quick communication permitting decentralized control, and for many, many other applications.

Another industry-shaper is maintenance. It is now vividly clear that preoccupation with new construction and technology resulted in expensive neglect of existing assets. It is also clear that we can no longer afford such neglect. Maintenance of roads, trackbeds, parts, vehicles--even maintenance of human assets--is vital to a healthy transportation industry. Making maintenance important and training people who can be leaders in maintenance are desperately needed.

A third trend is conservation of energy, natural resources, money, and people. This is the era of fiscal constraint; we must be smarter and tighter about spending the public's money. It is also the era of energy and resource constraint; we know we simply cannot squander our natural resources in the future as we have in the past. This means we have a growing emphasis on business-like practices emphasizing cost and budget. Choices will be even tougher in the future.

Another continuing trend is increasing public exposure of transportation issues. We know it will continue because these issues and decisions are important to society. Citizens care where the road will be built and what it looks like and how much noise it produces, and they have been given legal means to intervene.

Members of Congress earmark UMTA capital grants instead of allowing UMTA to decide them because transit investments make a difference to communities. Boards of directors and state legislators intervene deeply into what used to be management issues, partly because we have not helped them govern by policy, but also because budget, personnel, maintenance, and project control all matter to voters. And policy board members are understandably unwilling to leave such important matters entirely to the staff.

Finally, the transportation industry is being shaped today and tomorrow by a growing appreciation for the value of human resource development. This takes at least two forms: first, the transportation profession is becoming increasingly diversified. Earlier reliance on engineering and operations has expanded to embrace a variety of new disciplines, and within each discipline the basic curriculum is being broadened as engineers learn to manage and administrators are forced to acquire sophisticated quantitative skills. A second form of expression of the human resources movement is the growing recognition of individual needs. People are far less willing to do routine, boring work day after day. They want recognition, variety, responsibility, and they want opportunities for growth--on the assembly line, in the bureaucracy, and in the field. And they will not work for employers who do not or cannot offer such opportunities.

Perhaps you can think of other determinants, but even my short list is significant. What my list omits is any transforming change in transportation itself. I do not foresee the kind of change marked by the automobile and the airplane earlier in this century occurring. Our transportation world will, I believe, continue to rely heavily on the private automobile, the bus, the rail car, and the jet airplane in varying combinations, or roadways, to transport us. Television and the computer may reduce the need for movement. But delivering goods and moving people safely in an increasingly densely populated and economically interdependent world will make heavy demands on us.

What kind of professional do we want? What skills, education, abilities, and attitudes are we looking for? The transportation industry has been marked by change, and the next few decades will surely bring more changes in transportation patterns, technologies, and governance.

This points to several facets of our ideal employee profile: he or she must be equipped by education and temperament to deal with change. He or she must be flexible and adaptable to different kinds of work settings and instruments. This contrasts with employees in the past who have sought the routine, who have been rigid and inflexible, who have been frightened by change. I do not believe that they have served the industry well. I believe that we, employers, universities, faculties, and bosses, may have failed them by not reeducating them or helping them adapt.

The ideal employee will come from many different academic backgrounds, not just engineering or accounting or operations. Given the broad, decentralized nature of this industry, and the evident opportunities for travel and job mobility, a variety of disciplines are relevant and can help. Above all, though, a solid grounding in the arts and sciences as an undergraduate appears to be essential. It can provide an understanding of the more technical disciplines; it demands good communication skills, and it offers a base for continuing education. At the graduate level, education in engineering and planning will continue to be valuable. But so will degrees in the social sciences, business and public administration, and computer science.

For men and women who seek to be senior professionals, there is no substitute for them knowing their subject matter. It may be in planning, project management, procurement, law, accounting, or personnel. Those who want to be managers, especially top managers, must also have a solid base in a professional field. In addition, they must understand what it takes to manage large-scale systems, to succeed in the ambiguous world of politics, and especially to be able to make decisions that involve the allocation of limited resources. Above all, they must be leaders, keen at evaluating people and capable of motivating subordinates.

When I say keen at evaluating people and capable of motivating subordinates, I am referring to the most important dimension of a top manager's job: understanding the way people work and behave in organizations and understanding how organizations affect individuals. Only if a manager can grasp this can he or she begin to shape and change the organizational culture. The effective manager must learn to think in new ways, to lead his or her subordinates to think in new ways, and to improve an organization's performance rather than accept and continue in the accustomed organizational patterns and results.

The ideal employee must also develop a willingness to assume responsibility. By this I mean both the ability to take initiative and the courage to be accountable. Organizations run from the bottom up, and the transportation industry especially will not succeed if its employees in the future sit around waiting to be told what to do.

In addition, an essential part of the ideal employee's profile must be the ability to learn. He or she must have an eagerness, a curiosity, a willingness, and an attitude open to learning. He or she must know that a formal education has a half-life of 10 years or less. He or she must know that renewal is necessary. He or she must appreciate the value of teamwork with coworkers. He or she must know the importance of fundamentals such as personal health and integrity.

Now, with these broad strokes about the employee of the future, what can be said about preparing him or her? What is it we need from our colleges and universities? What contribution can transportation centers make?

Here, I am on thin ice--even thinner than before, especially given this audience of experts. But, having come this far, allow me to sketch the profile of the ideal university program.

Some of those deficiencies I mentioned earlier must be corrected. The transportation industry will not excel if its professionals do poorly and are not properly trained in written and verbal communication. I know this sounds simplistic--but I do not believe it can be overemphasized. As an employer, I have tried to hire only people who can write concisely, clearly, and correctly, and who can make a logical presentation.

Universities will also need to correct what appears to be a narrowing of the curriculum, and they need to resist the students' desire to specialize too soon. Young people have the next 50 years in which to specialize.

Research is badly needed. Part of it should be basic, and much of it must be applied. Applied research must be relevant to employers' needs--to the real problems of the transportation industry. Most of us know that this is not always the case. But we also know that it makes little sense for UMTA to spend one-third less on university research today than it did in 1970. Or to spend a paltry $70 million a year on highway research nationwide. What does make sense is the apparent new consensus in the highway program on research priorities, forged by the strategic transportation research study (1) led by TRB and assisted by AASHTO's select committee on research. We need such an effort in all of our surface transportation programs.

Continuing education in a variety of places and forms is an essential requirement of the ideal university. It must update professionals, it must offer retraining for those who want to change specialities, it must refresh and renew worn-out managers, and it must broaden and heighten the perspectives of public and private employees alike. It can especially serve to encourage new forms of public and private collaboration.

Universities must also recognize that they do not "provide" an education; at best, they should seek to teach students how to learn. Faculty become not merely instructors but "facilitators of learning," to use Thomas Larson's phrase. Students need to know not only how to acquire more knowledge, but how to evaluate what they do know, and how to apply it. They must also learn values that they can rely on, as well as what they need for personal growth and renewal.

Universities also need to find new ways to assist managers in understanding how people work and behave in organizations and how to change organizational cultures. A great deal of theory and some case studies have been provided by political science, business and public administration schools, and in other departments. But managers need more than theory; they need help. They need to learn how to apply knowledge in a specific context. Perhaps this is a role that transportation centers can usefully play. If they wish to play such a role, however, they must leave the campus and go inside the transportation department or authority. They must learn first-hand the bureaucratic dynamics, and they must experience the organization system in order to be helpful. Only then will they be in a strong position to help the manager lead his organization toward new levels of performance.

Finally, it appears that our university programs must emphasize the importance of human resources. Employers must do the same. The best companies--"in search of excellence"--know their success depends on the quality of their employees. This point is so obvious I hesitate to talk about it. But I believe our universities have neglected their first responsibility, not merely to educate and train transportation professionals and managers, but especially to help the industry know how absolutely critical our human resources are. For all the change that has occurred, and will occur, I suggest that the nurturing of our human resources is an enduring requirement. It, above all, is the key to excellence.

A few quick thoughts in closing. First, the crisis or opportunity facing the transportation industry holds the promise of a new era of cooperation and collaboration between universities and employers. Many signs of this already exist. But our common plight suggests that education and industry can both reap great benefits by new and more flexible forms of interaction: research programs, training grants, internships, job rotations, and other mechanisms.

Second, the transit program clearly needs a strategic research study that will harness the best educators and administrators in a hard-headed look at current and future research needs.

Third, let me suggest a different kind of study, one that might be called a human resources strategic plan. It would start with the deliberations of this conference and involve academic, private, and public people. It would profile in far greater depth than I can the changing professional requirements of the transportation industry. It would include a special emphasis on where our future leaders are coming from, similar to the Clark Kerr study of university presidents. And it would help colleges and universities understand how better to help young men and women acquire the education and training they need.

I began on a discouraging note. The challenges appear enormous. But we have a pretty good record over the past several decades, and by meeting here we can certainly define the problem and set an agenda. We know we have our work cut out for us. There may be no other subject in surface transportation that is more important.

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Future Demand for Transportation Professionals: The Outlook for Engineers in State Departments of Transportation

Damian J. Kulash and William A. Hyman

A generational shift is occurring in transportation agencies. Thousands of transportation professionals that were hired by federal, state, and local governments during the period of growth and prosperity following World War II are about to retire. The agencies that these professionals are leaving have hired relatively few new professionals during the last decade, as public programs have contracted or remained constant. A new generation of transportation professionals will soon be taking charge.

In state departments of transportation and county highway agencies, the dimensions of this turnover are exceptional. One-third of their engineers will retire during the coming decade. These organizations need to take special steps to recruit and train the needed talent.

But replacing the skills lost through retirement is only part of the solution. Some new skills will be needed as agencies adjust to future program priorities, future public expectations, and future technological capability. There will be new resources to meet the challenge as professionals from varied disciplines apply their skills to transportation, and as increasing numbers of women and minorities enter professional transportation fields. Public agencies now face a unique opportunity to reshape their organizations to do tomorrow's job, for tomorrow's citizens, using tomorrow's tools. Together with the nation's universities these agencies face a unique challenge to put in place the education and training that will equip tomorrow's professionals to deal with this challenge.

In response to a mandate included in the Surface Transportation Assistance Act of 1982, the Transportation Research Board assembled a committee, chaired by Lester A. Hoel, Hamilton Professor and Chairman, Department of Civil Engineering, University of Virginia, to examine future transportation professional needs at all levels of government. This paper contains information drawn from one part of the preliminary report of that committee, namely the outlook for entry-level engineers for state departments of transportation.

Among the many disciplines that contribute to state departments of transportation, engineers are a key group because nearly three-fourths of the 41,000 professionals now employed by state departments of transportation are civil engineers. Although future programs and public expectations of those programs will reshape the types of professional skills required, engineering programs will continue to supply a substantial portion of the professional staff within state departments of transportation. The number of state transportation professionals grew during the 1950s and 1960s as the nation's highway program grew, and it declined during the 1970s as the highway program stabilized and declined, in terms of constant dollars. With the passage of the Surface Transportation Assistance Act of 1982 and with increases in state-financed programs, the highway program started to grow again in the early 1980s.

With the network of roads and transit links largely in place, maintenance and rehabilitation of the existing highway and transit system will continue to be an abiding concern. Maintenance of roads, bridges, trackbed, buses, and other rolling stock will be essential to make the most efficient use of the nation's enormous investment in its transportation system. Some capacity expansion, however, will be necessary because of the inexorable growth of traffic in specific localities.

Continued attention will also be given to costs, not just monetary costs, but the broader costs implicit in natural resources and people. Budgetary pressures will continue to force fiscal constraint and conservation. Efficient use of existing facilities and services will continue to compete with capacity expansion as potentially cost-effective ways to meet the public's growing demand for transportation. Transportation professionals will become increasingly vigilant of ways to save the taxpayers' dollars and to spend money as wisely as possible. Those professionals will also continue to be held responsible for the environmental and safety implications of their actions.

During the next 15 years, the structure of the nation's chief transportation institutions probably will remain the same. The existing federal agencies, state governments, cities and counties, as well as regional agencies and special districts will continue to share the responsibilities for the improvement and care of transportation facilities.

The technology supporting this industry will benefit from the advantages offered by faster, smaller, and less expensive computers. Some manifestations of the work station of the future appear in some offices today--computer terminals near every desk, electronic mail, easy access to huge data bases, electronic word processors, decision-making tools such as simulation models and spreadsheets, and electronic engineering aids such as computer-aided design and drafting. Rapid change in engineering and office automation, as well as in field applications of computers, is expected. Construction and maintenance management systems for highway engineers will become more sophisticated and effective. Portable computers and telecommunications already available may allow engineers in the field to find better solutions to their problems with less paperwork.

The human resources that will be available to address transportation needs will also be evolving. Many transportation functions, particularly in state departments of transportation, have traditionally been performed by civil engineers. In many instances, rigid certification procedures have been established to ensure technical competency in design and construction projects that involve substantial public safety concerns and large expenditures of taxpayers' funds. Such procedures have also helped to insulate professional staffs from political patronage and to ensure that they work in the avowed public interest. Certainly, strong technical capability is crucial to success. For example, there is evidence that links the recent strong economic performance of Japanese industry compared with that in the United States to the relatively large fraction of engineers among production workers in Japan. Similarly, the construction of the Interstate highway system, which has been a dominant accomplishment of the current generation of state engineers, was done with remarkable efficiency, dedication, and integrity. Nevertheless, the basic skills that underlie these professional accomplishments--analytical ability, knowledge of physical systems and their properties, communications skills, and creativity--are not necessarily closely correlated with current certification procedures. As a result, nonengineering professionals complain of the lack of opportunity in some state departments of transportation, and they question the current relevance of certification procedures that were established in the era when top priority was given to rapid completion of necessary construction.

Provision of necessary skills, rather than disciplinary credentials, is the key concern. The future highway program, in which rehabilitation is as important as new construction and safety and other public concerns are growing in importance, may need a different set of professional qualifications than did past programs. Reflecting this broadening of skill requirements, increasing numbers of state chief administrative officers now come from fields other than engineering. Whether there should be greater diversification in the professional ranks is a complicated question that depends on each agency's civil service laws, agency composition, availability of candidates, and other factors. Nevertheless, now is the time for state departments of transportation to ask the question, in anticipation of high rates of future turnover and the opportunity for redirection that the coming decade will bring.

In the coming decade, slow growth in state highway programs--perhaps 1.8 percent per year--appears likely. Allowing for growth in productivity, this means that professional staffs in state departments of transportation may grow by about 1.1 percent per year. At the same time, high rates of retirement will create serious stress for many state departments, particularly those that did little or no hiring throughout the 1970s. Overall, an average of about 3.1 percent of professionals are projected to retire each year throughout the coming decade. This is far higher than the average of 1.9 percent experienced by civil engineers in general.

Most of the positions vacated by retiring engineers during the next 5 to 10 years will require far more background and experience than can be provided by new entry-level engineers who will soon be starting their careers. Nevertheless, the pending surge in retirements within state departments of transportation will initiate a sequence of promotions and reorganizations which, when traced through the organizational hierarchy, will ultimately lead to an upturn in the number of entry-level engineers that states hire. Ensuring an adequate supply of new graduates is part of any long-term resolution of professional needs.

The output of the nation's educational system is at a turning point, however. In the past 15 years, college enrollments have risen as the baby-boom generation entered college and as the proportion of high school graduates entering college increased. The coming decade will bring a decline in the size of the college-age population, and the fraction of that population entering college will not be growing. The result is that the number of college enrollments will decline in the years ahead. Further, the share of these graduates that enter civil engineering may continue to decline. Although this share has declined throughout the last decade, the effect was not obvious in the job market because baby-boom-driven increases in the total number of graduates more than offset the ever smaller share of these graduates studying civil engineering. Thus, the number of civil engineers increased even as the share of engineering students entering civil engineering dwindled. The coming decade begins with both these trends headed downward--both total graduates and the civil engineering share. The result is that the number of civil engineering graduates will decline rapidly, and this could lead to shortages of qualified entry-level engineers several years hence unless recent trends are reversed. In examining whether the future supply of entry-level engineers to state highway agencies will be sufficient, it is helpful to focus separately on five components:

- The outlook for future college enrollments in general, particularly in engineering fields;
- The share of engineering students entering civil engineering;
- The number of new graduates that are United States citizens and able to work in the United States;
- The proportion of these graduates that state highway agencies recruit; and
- How the number of new engineers that states recruit compares with the number of new recruits needed.

Each of these five components is explored in sequence later in this paper. Before turning to future trends, however, the current market for civil engineers is sketched briefly.

CURRENT MARKET FOR CIVIL ENGINEERS

Currently there appears to be an adequate supply of civil engineers available to the states. Various labor market indicators support this conclusion:

- Low job and salary offers to new engineering graduates,
- Small changes over time in the salaries of state highway engineers relative to other types of engineers in positions of comparable responsibility, and
- Few major industrial employers reporting a lack of qualified applicants for civil engineering job vacancies.

The College Placement Council reports the number of job offers to new graduates receiving bachelor's degrees in civil engineering more than doubled from 1977 to 1981 but then plummeted by 80 percent in 1983, probably largely in response to the severe recession in the construction industry (Table 1). In contrast, job offers to electrical engineers have been two to three times the level of offers to civil engineers and declined only 23 percent from 1981 to 1983.

TABLE 1 Number of Job Offers to Recipients of Bachelor's Degrees in Civil Engineering and Electrical Engineering, 1974-1983 (1)

Year	Civil	Electrical[a]
1977	2,178	6,106
1979	4,424	10,742
1981	4,416	10,768
1983	892	8,285

Note: As reported to the College Placement Council.

[a] Including computer sciences.

Average monthly starting salaries of new recipients of bachelor's degrees in civil engineering declined in current dollars from $1,925 in July 1982 to $1,869 in July 1983. In real terms, this 1983 salary was lower than for most other engineering disciplines. In addition, the starting salaries of civil engineers with bachelor's degrees had fallen below the 1974 level in real dollars, unlike the starting salaries of electrical, aeronautical, industrial, and mechanical engineers, which had risen (Table 2). The real salaries that state highway engineers receive relative to engineers of all types in the private sector with similar responsibility have also declined from 1975 to 1983 (Table 3).

TABLE 2 Average Starting Salaries of Recipients of Bachelor's Degrees in Various Engineering Curricula, 1975-1983 (1)

Year	Civil	Electrical[a]	Aeronautical	Industrial	Mechanical
1974	2,064	2,105	2,052	2,090	2,137
1983	1,976	2,249	2,118	2,164	2,215

Note: As reported to the College Placement Council (salaries in 1984 dollars).

[a] Including computer science.

TABLE 3 Index of Change in Average Salaries of Selected Classes of State Highway Engineers Relative to Average Salaries of All Types of Engineers with Comparable Responsibility in Private Industry (2-5)

Year	State Highway District Engineer[a]	Private Sector Engineer with Comparable Responsibility[b]	State Highway Project Engineer[a]	Private Sector Engineer with Comparable Responsibility[b]
1975	0.80	1.03	0.59	0.93
1976	0.83	1.03	0.66	0.93
1979	0.76	1.04	0.53	0.92
1983	0.76	1.09	0.55	0.96

[a] Average salaries of district and project engineers obtained by taking the midpoint of the salary range for each state reported in the AASHTO Highway Salary Survey (2) and then calculating the mean over all states.
[b] From AASHTO Transportation Salary Survey (3). Index created by dividing average salaries of types of employees shown in table by average salaries of Attorney IV in the same year. Attorney IV is defined in the AASHTO Transportation Salary Survey (3). This procedure corrects for changes in cost of living.

All of these salary trends suggest that the market for civil engineers has been soft for a decade, and there has been a more than ample supply of civil engineers in the last 2 years.

Only a small percentage of major industrial employers of engineers reported to the National Science Foundation that there have been insufficient qualified applicants to fill vacant civil engineering positions. The percentage of employers reporting such difficulties dropped from 12 percent in 1981 to 3 percent in 1984 (Table 4). The corresponding percentages were substantially higher in many other fields, suggesting that the supply of qualified civil engineers was greater, compared to the demand, than was the case in many other fields. The current salary structure in civil engineering may change in future years as the excess supply of highway professionals evaporates.

Currently, salaries (midpoint of the salary range) for highway professionals, such as district highway engineers, are significantly lower in the southeastern part of the United States compared to other portions of the country (Table 5). There appears to be no significant difference among salaries of highway engineers in other portions of the country.

TABLE 4 Percent of Private Sector Firms Reporting Insufficient Qualified Applicants for Various Engineering Positions

	Type of Engineering			
Year	Civil	Electronic	Computer	Petroleum
1981	12	58	51	65
1982	4	32	21	19
1983	5	7	6	7
1984	3	12	15	4

Source: National Science Foundation.

Such comparisons do not reflect variations in employee benefits, differences in regional cost of living, or differences in working conditions. Currently, state employee benefits in transportation agencies range from 16 to 59 percent of employee salaries, the mean being 36.5 percent (Table 6).

A 1983 salary survey of the Institute of Transportation Engineers (ITE) indicates that the mean salary of ITE members in state government, $35,140, is among the lowest in the civil engineering industry, nearly $8,000 below the mean level the federal government pays, and more than $5,000 below the amount consultants receive in private practice (Table 7). Members of ITE in public transit and academia also receive higher salaries than those in the states. These salary levels have not been adjusted to account for the length of experience of employers, which normally explains a large portion in the variation from one employer to another.

OUTLOOK FOR COLLEGE ENROLLMENTS

Since 1960 the most important demographic trend affecting college enrollments has been the dynamics of the baby boom. Beginning around the mid-1960s, the large group born immediately after World War II began entering college, and for about 10 years, college enrollments rose rapidly. A further stimulus to the growth in college students was the increase in the number of women and minorities entering higher education. From 1960 through 1975 total college enrollment of persons in the 18 to 24 age bracket rose from 2.2 million to 6.9 million. Female enrollments

TABLE 5 Salary Ranges of Key Professional Positions in State Departments of Transportation and Highway Organizations, 1983-84 (4)

State	District Engineer	Project Engineer	Graduate Civil Engineer (BSCE)	Journey Level Transportation Planner
Alabama	33,826-51,610	19,739-29,900	21,772-33,020	25,168-38,324
Alaska	N/A	38,124-45,192	26,892-32,040	43,560-51,588
Arizona	34,352-46,637	29,516-35,528	20,970-24,713	22,038-28,975
Arkansas	40,760	28,808-37,622	16,328-23,348	27,560-36,400
California	34,548-52,980	30,756-37,116	19,812-22,764	24,876-30,012
Colorado	39,576-50,508	25,512-32,556	21,576-24,972	34,188-43,632
Connecticut	34,475-42,320	24,911-30,328	20,382-22,968	24,911-30,328
Delaware	26,669-44,604	23,325-36,977	15,382-25,057	24,946-40,688
District of Columbia	51,058-63,700	43,410-56,424	14,054-18,284	14,054-18,284
Florida	37,000-67,500	20,859-28,417	16,307-21,882	N/A
Georgia	27,996-43,004	18,390-27,996	19,152-25,722	18,390-27,996
Hawaii	30,228-48,156	23,844-36,000	16,116-23,844	21,768-32,820
Idaho	32,801-48,484	23,296-34,444	17,388-25,688	19,117-28,329
Illinois	31,620-46,800	25,200-36,900	19,800-25,800	21,000-30,780
Indiana	26,546-41,340	21,112-31,070	19,500-28,860	17,342-25,636
Iowa	30,909-41,704	24,484-32,716	18,907-24,690	17,909-21,965
Kansas	32,256-44,736	22,656-31,308	19,092-26,436	17,484-23,676
Kentucky	29,856-47,808	22,272-35,688	15,072-24,144	16,608-26,592
Louisiana	34,308-49,740	24,336-36,036	21,216-30,756	26,052-37,608
Maine	24,024-33,530	20,584-27,976	16,058-21,902	17,638-24,086
Maryland	31,132-44,165	21,237-27,894	16,995-22,316	21,237-27,894
Massachusetts	34,528-43,086	22,495-27,799	18,646-22,742	30,194-37,557
Michigan	36,561-49,026	39,609-52,993	19,585-24,764	22,446-30,380
Minnesota	36,310-48,170	26,956-35,934	21,151-26,016	19,606-25,766
Mississippi	31,223-46,572	22,019-32,976	17,427-26,089	17,427-26,089
Missouri	38,200-48,000	21,948-30,384	19,200-22,056	21,948-30,384
Montana	32,212-41,316	20,785-28,311	16,159-22,093	17,475-23,861
Nebraska	30,219-42,307	22,629-31,681	19,126-25,501	16,944-23,722
Nevada	30,951-42,547	23,751-32,367	20,888-24,805	20,021-27,090
New Hampshire	24,005-29,660	21,333-26,150	14,567-17,628	17,004-20,495
New Jersey	36,177-48,833	26,995-36,446	19,139-20,010	23,318-31,483
New Mexico	32,184-45,300	26,472-43,140	17,916-29,196	17,064-27,804
New York	57,718-68,172	30,326-41,403	18,718-22,338	28,772-33,740
North Carolina	28,560-43,836	21,468-32,856	19,212-20,088	17,928-27,216
North Dakota	28,956-42,420	21,600-31,644	16,128-23,628	16,932-24,804
Ohio	29,099-41,350	19,781-27,622	17,992-23,941	16,557-21,778
Oklahoma	39,271-52,626	23,383-38,313	18,429-24,697	23,521-31,520
Oregon	34,044-43,428	25,368-32,376	18,084-23,100	N/A
Pennsylvania	37,653-48,098	21,379-29,066	17,976-23,276	21,379-29,066
Puerto Rico	17,220-21,720	13,260-16,860	11,280-14,280	10,380-13,080
Rhode Island	N/A	20,883-23,577	18,681-21,733	23,429-26,531
South Carolina	27,191-38,540	19,867-28,159	16,982-24,071	18,368-26,036
South Dakota	35,500	20,134-31,325	17,014-26,104	15,662-23,837
Tennessee	22,200-29,052	18,840-25,188	16,404-22,200	14,592-20,172
Texas	50,000-52,700	31,968-40,272	23,784-29,952	25,392-31,968
Utah	34,076-49,778	24,868-36,269	19,773-26,058	17,811-26,058
Vermont	21,299-40,477	16,973-32,032	13,562-25,189	16,973-32,032
Virginia	28,397-38,781	15,213-20,791	18,183-20,791	19,884-27,150
Washington	43,740-55,992	26,700-34,176	17,988-23,016	17,988-23,016
West Virginia	28,464-50,988	22,284-38,316	16,884-28,872	14,724-25,080
Wisconsin	38,275-53,198	24,785-32,675	20,664-25,478	24,883-34,584
Wyoming	37,968-58,908	29,640-45,984	19,968-30,984	19,475-30,240

TABLE 6 Employee Benefits as a Percent of Average Salaries of State Highway Agencies

State	Benefits Expressed as a Percentage of Average Salary	State	Benefits Expressed as a Percentage of Average Salary
Hawaii	59	Nevada	35
New York	55	Tennessee	33
Missouri	54	West Virginia	33
Maryland	52	Arkansas	32
Florida	50	Delaware	32
Iowa	50	Minnesota	32
Ohio	49	California	31
Alabama	48	New Jersey	30
Mississippi	46	Washington	30
Oregon	46	Rhode Island	29
Louisiana	45	Virginia	29
North Carolina	44	Wisconsin	29
Colorado	43	Vermont	28
Oklahoma	43	North Dakota	25
Idaho	42	Massachusetts	24
Texas	41	New Hampshire	20
Utah	41	New Mexico	20
Kentucky	40	Montana	18
Nebraska	39	South Carolina	17
Illinois	38	South Dakota	16
Kansas	37	Alaska	n.a.
Wyoming	36	Arizona	n.a.
Connecticut	35	Georgia	n.a.
Maine	35	Indiana	n.a.
Michigan	35	Pennsylvania	n.a.

Note: n.a. = not available.

Source: American Association of State Highway and Transportation Officials survey of state departments of transportation and highway agencies for the Transportation Professional Needs Study, Supplement, 1984.

increased from 0.8 million to 2.8 million, and black enrollments increased from 134,000 to 665,000. Meanwhile, the United States population was growing from 179.3 million to 214.9 million (7).

After 1975 the 18 to 24 age group both in and out of college stabilized at around 30 million and has remained at that level from 1979 through 1982. Meanwhile, the high school population has been declining, portending a drop in college enrollments in the last half of the 1980s (7).

Since 1960 the total number of engineering degrees has fluctuated, but the long-term underlying trend has been one of growth (8) (Figure 1). Various economic forces and government actions have spurred this growth. For example, the federal government increased student financial aid after the Russians launched Sputnik; the space program created a large extra demand for engineers; and rapid growth in the computer and microelectronic industry has greatly increased the

TABLE 7 Mean Salary of Members of the Institute of Transportation Engineers by Type of Employer (6)

Employer Category	Mean Salary ($)
Association	45,577
Manufacturer/supplier	45,429
Other	43,250
Federal government	43,245
Private practice	40,764
Public transit	39,408
Academic	38,024
City/local government	35,627
State/province government	35,140
County government	35,012
Regional transportation	33,363

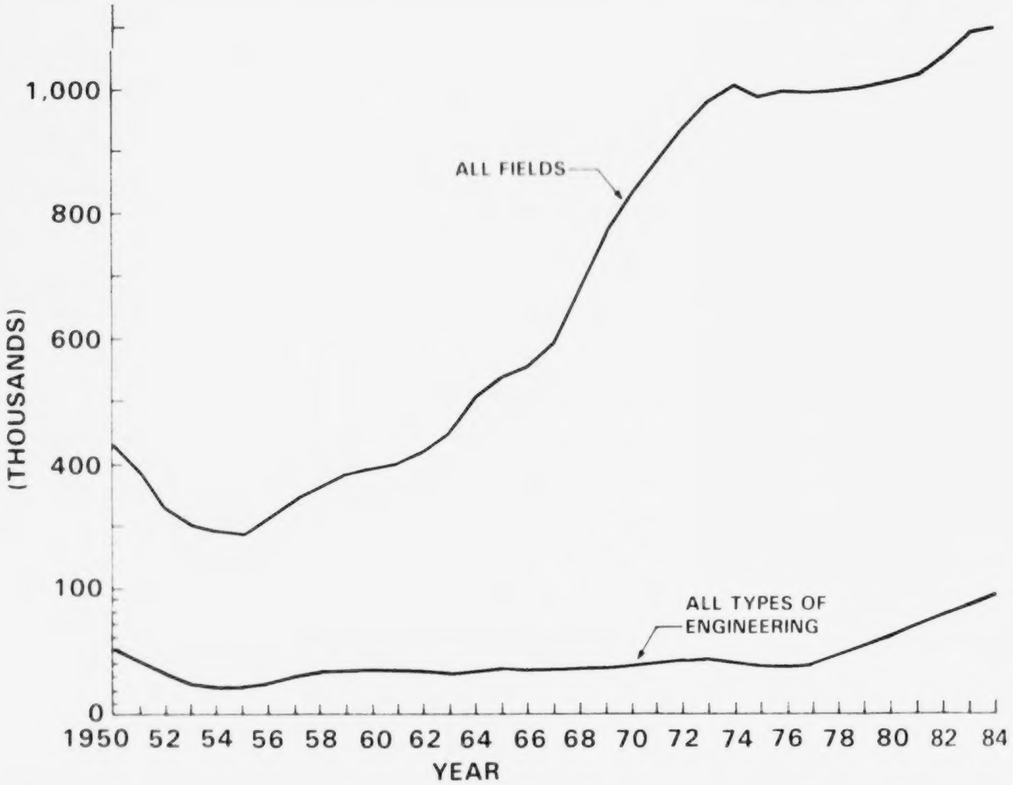

FIGURE 1 Bachelor's and first professional degrees (1).

demand for engineers. From 1970 to 1980 the total number of engineering degrees increased from 42,966 to 58,742, and according to the Engineering Manpower Commission, had reached 72,471 by 1983 (9,10). In the next 2 years declining college enrollments will cause the number of engineering degrees to decline. The number of bachelor's degrees in engineering will decline from 75,999 in 1984 to 71,372 in 1989, and master's degrees will decline from 16,310 to 15,930.

Share of Engineers Entering Civil Engineering

Bachelor's degrees awarded in civil engineering increased from 6,526 in 1971 to 10,524 in 1972. During this same period, master's degrees awarded in civil engineering increased from 2,425 to 2,995 (Table 8). In relative terms the growth in the number of bachelor's and master's degrees awarded to women in civil engineering was dramatic, an increase of more than 20 fold, but this increase still represents only about 1,000 people. Thus, the fraction of women recipients of bachelor's degrees is still only about 10.3 percent of all students earning bachelor's degrees in this field in 1982, according to the National Center for Education Statistics. The percentage of women receiving bachelor's degrees in civil engineering is less than the percentage of women receiving degrees in all branches of engineering, which in turn is far below the fraction of women earning bachelor's or first professional degrees in business (39 percent), law (52 percent), and veterinary science (46 percent) (Table 9). The number of blacks receiving bachelor's degrees in civil engineering has also greatly increased but is likewise far smaller than the black share of the population.

TABLE 8 Number of Civil, Construction, and Transportation Engineering Degrees

	Bachelor's (4 or 5 years)			Master's			Doctor's Degree		
Year	Total	Men	Women	Total	Men	Women	Total	Men	Women
1981-1982	10,524	9,333	1,191	2,995	2,725	270	329	315	14
1980-1981	10,678	9,557	1,121	2,891	2,684	207	325	316	9
1979-1980	10,326	9,349	977	2,683	2,476	197	270	264	6
1978-1979	9,809	8,865	944	2,646	2,503	143	253	249	4
1977-1978	9,135	8,450	685	2,685	2,553	132	277	271	6
1976-1977	8,227	7,799	429	2,964	2,835	129	309	303	6
1975-1976	7,923	7,657	248	2,999	2,900	99	370	361	9
1974-1975	7,651	7,509	142	2,769	2,695	74	356	347	9
1973-1974	8,017	7,889	127	2,652	2,603	44	368	364	4
1972-1973	7,390	7,318	72	2,627	2,589	38	397	388	9
1971-1972	6,803	6,741	62	2,487	2,449	38	415	413	2
1970-1971	6,526	6,474	52	2,425	2,397	28	446	443	3

Source: National Center for Education Statistics, annual series, 1948-1980.

Although the number of civil engineers has been increasing, this growth makes a strong downward trend in the relative popularity of civil engineering degrees. For almost a decade, a smaller and smaller share of engineering graduates has

TABLE 9 Approximate Percentages of Women Enrolled and Graduating in the Professional Fields, 1984 (11)

Profession	First Year Enrollment	Bachelor's and First Professional Degrees
Business managers	43.7[a]	39.3
Architects	28.4[a]	29.8
Engineers	15.8	13.2
Lawyers	38.4	50.8
Physicians	31.6	26.7
Dentists	24.4	20.6
Optometrists	26.7	22.0
Osteopaths	25.4	19.8
Podiatrists	20.7	10.5
Veterinarians	48.6	46.4
Pharmacists	53.9	49.4

[a] Undergraduate.

selected civil engineering as a specialty. The share of engineering degrees awarded to civil engineers dropped from about 20.3 percent in 1976 to 15.7 percent in 1982 (Figure 2). Similarly, the share of all master's degrees in engineering awarded to civil engineers showed a parallel decline until 1980, but then rose in 1981 and 1982. Some of this upturn in master's degrees may have occurred as students deferred entering a slack labor market and tried to improve their long-term earning potential by seeking an advanced degree.

Enrollment data on the number of students in civil engineering reveal some interesting trends that will also affect future degrees awarded in civil engineering (12). First, in the mid-1970s most students who selected civil engineering as a specialty made the choice in their freshman or sophomore years. At the time, students were undoubtedly responding to the previous growth in civil engineering employment opportunities and expectations of future opportunities. By the 1980s the demand for civil engineers had declined relative to the demand for other types of engineers, particularly electronic engineers, and fewer students elected civil engineering early in their college years. In addition, although many university engineering programs became more specialized, in some programs students were encouraged to avoid specialization until later in their academic program. It is also possible that increasing numbers of students receive general engineering education in 2-year colleges and then specialize when they switch to a 4-year college or university program.

Enrollment data strongly suggest that since 1980 an increasing share of graduates has selected civil engineering at the last moment--in the fourth year of undergraduate work. Each of the lines in Figure 3 shows the size of each graduating class of civil engineers as it progresses through its 4-year curriculum. For example, the class of 1978, shown to the left of the figure, had only about 8,000 members in 1975, the freshman year. But this number grew to about 10,000 in 1976, the sophomore year, and to more than 12,000 by 1978, when the class graduated. By 1978, however, there is virtually no increase in the number of civil engineers between freshman and sophomore years, as is apparent from the flat leftmost portions of the curves for the classes of 1981 through 1985.

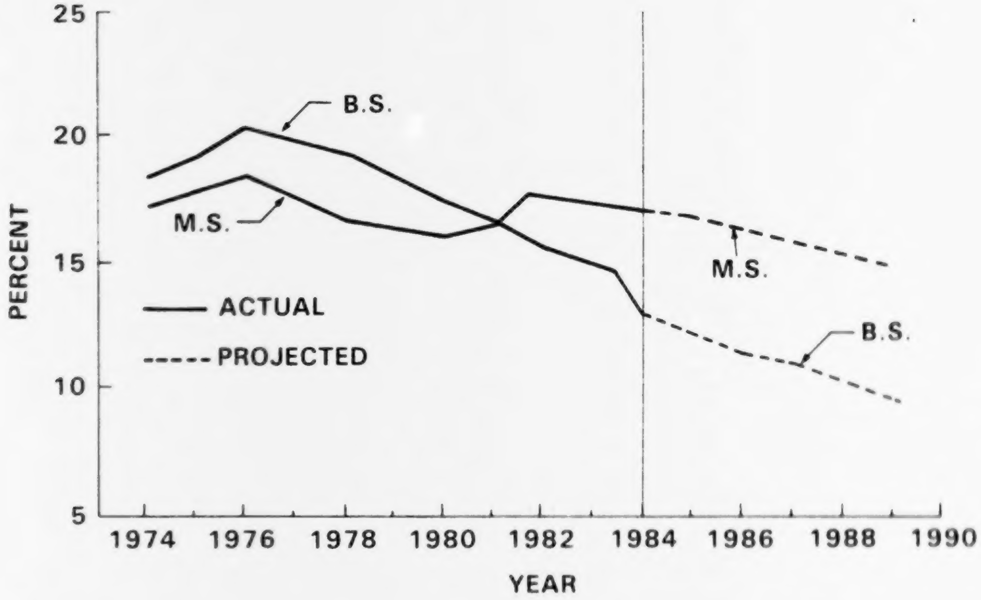

FIGURE 2 Civil Engineering graduates as a percent of all engineering graduates (9-10).

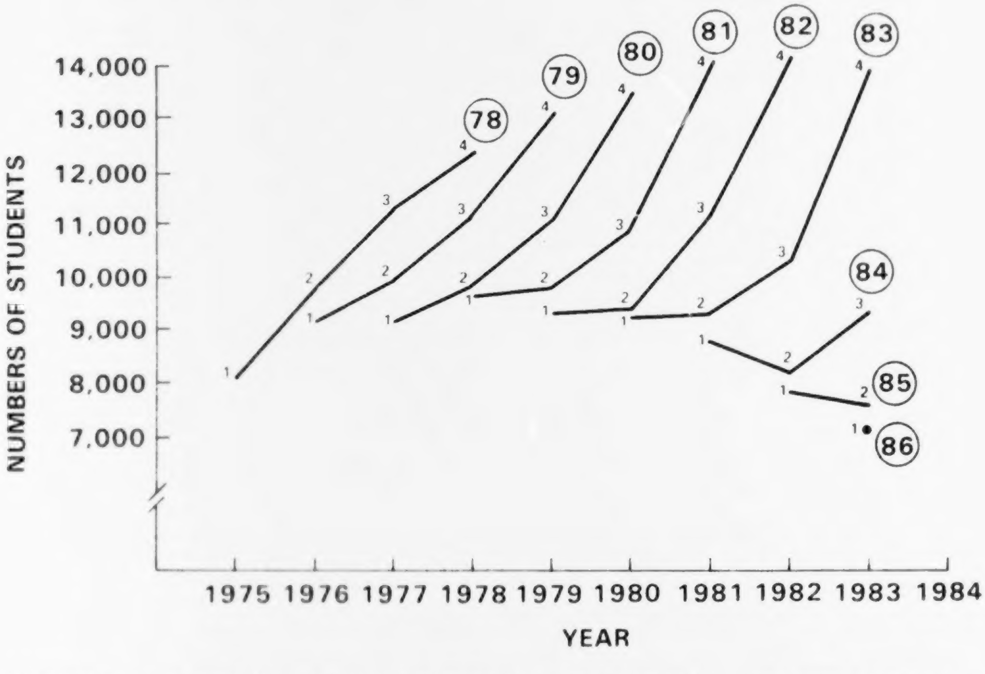

FIGURE 3 Trend in civil engineering enrollments (undergraduates). Note: 1, 2, 3, and 4 representing first-, second-, and fourth-year civil engineering undergraduate enrollments for the class due to graduate in the spring of the circled year.

Indeed, the number of civil engineering enrollments remains relatively static until the senior year, when a substantial number of students select civil engineering. By the time the class of 1983 went to college, the number of students enrolled in civil engineering in their junior year was only about 1,000 more than the number enrolled as freshmen. The only sizable increase occurred in the final year, when nearly 4,000 students enrolled in civil engineering in their senior year.

To some degree, this shift in the dynamics of civil engineering enrollments within the 4-year curriculum may be due to the inability of some students to complete engineering degrees in other fields because of overcrowded courses or to compete against the better students who selected fields of study in computers, genetic engineering, robotics, or other fields that receive extensive publicity and that attract many of the best students. Those students that choose to remain within a general engineering curriculum instead of specializing may account for part of the change in enrollment patterns, and so may the increasing number of students taking their early general engineering courses in 2-year colleges.

The tendency toward late selection of civil engineering as a major suggests that civil engineering may be a second choice for some students. To the extent that this is true, then the civil engineering share could erode still further even as popular competing courses become less crowded as college enrollments fall. Nevertheless, it is assumed here that the share of students enrolled in civil engineering fields continues to taper off according to the historic pattern, and no faster, as shown in Figure 2.

U.S. Citizens

A large proportion of civil engineering graduates are foreign citizens who are legally unable to accept jobs in the United States upon graduation. Eight percent of bachelor's degree recipients, and 26 percent of master's degree recipients were foreign nationals in 1979, according to an unpublished report to the National Science Foundation titled "Projections of Supply Scientists and Engineers to Meet Defense and Non-Defense Requirements, 1981-1984." This means that about 1,500 civil engineering graduates out of the national total of about 13,500 must return to their native countries and are not eligible to work in the United States upon graduation. Many of these graduates do eventually reenter the United States labor market, however. Immigration of civil engineers to the United States in 1984 has been estimated to be about 750 per year, equivalent to roughly one-half the number of foreign students graduating in civil engineering each year (13).

The high proportion of foreign nationals has also been a source of concern to educational institutions as they plan to meet their professional needs. The low number of United States citizens choosing to earn doctorates has been identified as a key problem that educational institutions now face. Colleges and universities are concerned that they have adequate faculty resources to continue their programs during the coming decade (13).

SHARE RECRUITED BY STATE HIGHWAY AGENCIES

Although the vast majority of professionals within state highway agencies are civil engineers, they comprise only a small part of the nation's trained civil engineers. To be counted among the civil engineers working in state departments of transportation, three conditions must be met. The engineer must be employed, must be practicing civil engineering, and must be employed by a state agency. First, between 7 and 9 percent of civil engineers do not enter the labor force, either because they go on to graduate school, because they are unable to find jobs, or because of some other reason (14).

Second, of those taking jobs, only about 80 percent or more will work in areas of civil engineering (15). Some shifting in and out of fields is expected because individuals have unique opportunities, including jobs in family businesses, in firms experiencing local shortages, or in other fields. Nevertheless, market forces heavily influence these patterns. Fields experiencing shortages of qualified professionals, such as computer science, draw candidates from other areas. Fields with a surplus of trained professionals lose some of their graduates to jobs in areas where job openings are more abundant. A net loss of trained civil engineers to other fields thus probably partly reflects a slack market for civil engineers.

Third, allowing that some civil engineering graduates do not take jobs at all, or take them in areas other than civil engineering, it is important to recognize that only 17 percent of the nation's civil engineers work in state highway agencies. Most of the 10,000 new civil engineers graduating each year take jobs in industry, consulting, local government, state government, and various other sectors (16). Assuming that this trend continues in future years, state highway agencies will need to recruit a corresponding percentage of new civil engineering graduates. Variations from this percentage will arise due to the large number of retirements expected within state departments of transportation, the more rapid growth of jobs for civil engineers in other organizations, and various other factors. Nevertheless, to make trends in academic enrollments comparable to trends in state professional needs, a useful benchmark is to assume that states continue to attract 17 percent of all civil engineering graduates, and then to assess the implications of the resulting figures. This exercise shows that, although there will be more candidates than jobs for the next 2 years, this situation will be reversed beginning in 1986. Thus the job market for entry-level engineers for state highway agencies promises to tighten up, as discussed next.

FUTURE AGENCY NEEDS COMPARED WITH FUTURE SUPPLY OF GRADUATES

Based on the preceding discussion, the following assumptions appear to offer a reasonable basis for projecting the future supply of graduating civil engineers available to state departments of transportation:

- The number of graduates in all fields of engineering will decline from 75,999 in 1984 to 71,372 in 1989 because of the declining college-age population, as forecast by the Scientific Manpower Commission (9);
- The share of these graduates entering civil engineering will continue to decline by about five percentage points per year (17) (American Society of Civil Engineers Enrollment Information, Fall, 1983);
- About 8 percent of recipients of bachelor of science degrees in civil engineering and about 26 percent of recipients of master of science degrees will be foreign nationals who must leave the United States upon graduation (16);
- Between 750 and 800 foreign nationals with degrees in civil engineering will immigrate to the United States each year (13);

- Between 7 to 9 percent of civil engineering graduates will not enter the labor force (16);
- About 20 percent of graduating civil engineers will be employed in fields other than civil engineering (15); and
- About 17 percent of all civil engineers entering the labor force will be hired by state departments of transportation.

Each of these factors is uncertain and subject to fluctuation, but before discussing some of the adjustments that might occur, and indeed probably would occur, it is instructive to examine the implications of the foregoing trends if they continue unchanged. Together, these assumptions imply that state departments of transportation sought about 1,450 new entry-level civil engineers in 1984, and that the states' pro-rata share of civil engineering graduates number about 1,630 in 1984 (Table 10). In 1985 state requirements will increase slightly to about 1,470 entry-level engineers, and the state share of national graduates available to take jobs will still be somewhat larger. In 1986 through 1989, however, the number of engineers projected to be needed by the states is beneath their pro-rata share of engineering graduates. Then, if the trends assumed earlier do not change, the states could find that they are unable to hire sufficient numbers of new graduates. This does not suggest that a shortage is likely, however. Rather, it suggests that some of the trends will shift in response to state needs. For example:

TABLE 10 Supply of New Civil Engineering Graduates and Other New Entrants to State Highway Organizations and Comparison with Requirements

	Supply		Requirements				Future Labor Market Conditions		
Year	Total Addition to Supply in U.S.	Number Supplied to State Highway Agencies	Total Engineers	Net Growth (Allowing for Productivity Improvements)	Attrition (Retirements and Deaths)	Total Requirements	Change in Supply	Change in Demand	Surplus/ Shortage
1984	9,440	1,630	29,969	529	916	1,450	1,630	1,450	+180
1985	8,990	1,550	30,508	539	933	1,470	1,550	1,470	+80
1986	8,500	1,460	31,057	549	949	1,500	1,460	1,500	-40
1987	8,000	1,380	31,616	559	966	1,530	1,380	1,530	-150
1988	7,590	1,310	32,185	569	984	1,550	1,310	1,550	-240
1989	7,210	1,240	32,764	579	1,002	1,580	1,240	1,580	-340

- The share of practicing civil engineers state highway agencies attract could increase above their historic, pro-rata share. As turnover in state agencies creates new openings and enhances the advancement potential for entering employees, more new employees may be attracted to state agencies. As long as other prospective employers of civil engineers are not experiencing shortages, probably state agencies could succeed in bidding for a larger share of new graduates. However, using assumptions similar to those preceding--especially the declining fraction of engineering students selecting civil engineering--it appears that the market for civil engineers of all types will be much tighter by the end of the decade (Figure 4). The accuracy of any such forecast is too poor to permit much confidence in forecasts for individual years. Even so the ability of the states to attract a disproportionate share of new civil engineering graduates would probably be short lived.

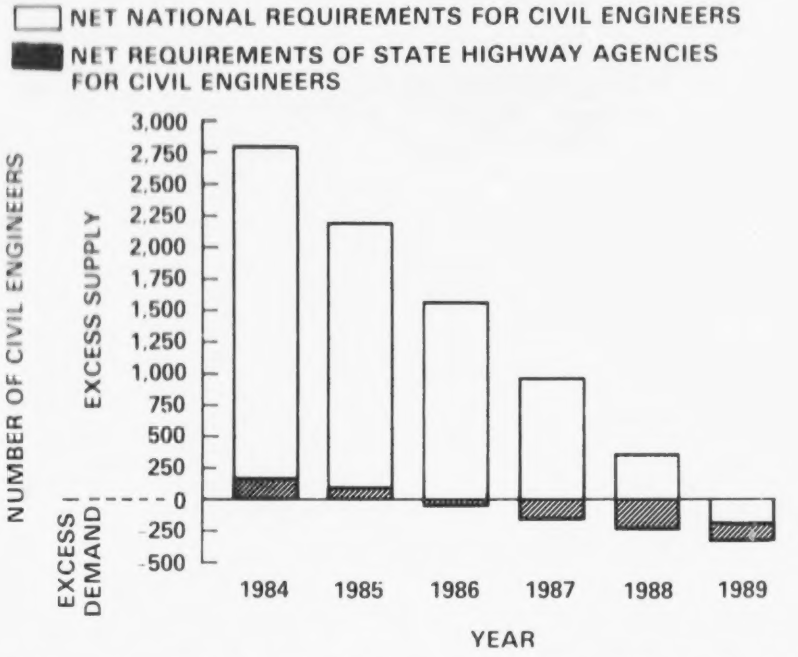

FIGURE 4 The net requirements for the nation's civil engineers and for civil engineers entering state transportation organizations, 1984-1989.

- The decline in the share of engineering students attracted to civil engineering could abate or halt as job opportunities improve; the share could even increase. This adjustment would probably take several years. Some time would elapse before students recognize better job opportunities and make curriculum choices based on new expectations. The lagged response of students' curriculum choices to future job opportunities might not be as large if the states take special steps now to increase student awareness of future potential. For example, expanded recruitment efforts, greater distribution of material on summer jobs, and cooperative working arrangements for students could help stimulate more student interest in civil engineering. Similarly, there may be ways to cooperate with professional societies to enhance their dissemination of job information.
- The portion of trained civil engineers that take jobs in other fields will probably decrease as job opportunities in civil engineering increase. As the labor market adjusts to improved job opportunities within civil engineering, the new equilibrium that emerges will probably be characterized by a smaller outflow of trained civil engineers into these fields.

- Business schools are now graduating close to 2,000 students per year who have earned transportation and public utility degrees (Table 11). Although most of these business students enter the private sector, they represent an additional source of skills state agencies can draw upon. As the labor market for civil engineers tightens, states may find it not only necessary but desirable to draw increasingly on graduates of transportation-related programs such as business, operations research, geography, and economics. Such graduates have learned skills particularly applicable to planning and investment analysis. With the continuing shift toward maintaining and optimizing the use of existing facilities, these skills will, in many instances, be as useful as traditional civil engineering skills.

TABLE 11 Number of Transportation and Public Utility Degrees

	Bachelor's (4 or 5 years)			Master's			Doctor's Degree		
Year	Total	Men	Women	Total	Men	Women	Total	Men	Women
1981-1982	1,816	1,431	385	129	116	13	2	1	1
1980-1981	1,538	1,275	263	120	111	9	3	3	-
1979-1980	1,322	1,067	255	142	121	21	4	4	-
1978-1979	1,151	940	211	134	130	4	3	2	1
1977-1978	1,084	932	152	158	151	7	1	1	-
1976-1977	1,124	979	145	125	115	10	6	5	1
1975-1976	1,057	958	99	108	103	5	3	3	-
1974-1975	812	747	65	117	116	1	2	2	-
1973-1974	618	588	30	109	109	-	2	2	-
1972-1973	567	548	19	159	157	2	9	8	1
1971-1972	644	641	8	66	66	-	6	6	-
1970-1971	662	656	6	63	63	-	3	3	-

Source: National Center for Education Statistics, annual series, 1948-1980.

Because of the likelihood of adjustments such as these, the projections in Table 10 are not interpretable as evidence of a pending shortage. Rather, they indicate that the surplus of civil engineers, which has been characteristic of recent years, is ending. A recent National Science Foundation study of science and engineering needs for the defense and civilian economy concluded that there would be sufficient civil engineers to meet the nation's growth in requirements through 1987. But the study noted that economic efficiency and labor market performance are not necessarily maximized when supply and demand are in balance. Unless requirements are met with "experienced and appropriately trained" personnel, the quality of the work force will diminish (13).

In a report of the National Research Council's Committee on the Education and Utilization of the engineer it was observed that civil engineers have been in oversupply due to the impact of the recent recession on the construction industry and a reduced demand for environmentally related work. The committee then cautioned that neither shortage nor surplus conditions are static (14). A joint study of the Bureau of Labor Statistics and the National Science Foundation, prepared in 1980, indicated that there would be an adequate supply of most types of engineers in 1990, including civil engineers, provided there was not a sharp increase in the defense budget (17).

CONCLUSION

If current trends in college civil engineering enrollments continue, the number of entry-level professionals needed by state departments of transportation will exceed their historical share of civil engineering graduates beginning around 1987. This means that state departments of transportation, to meet future professional staff requirements, will need to stimulate more enrollments in civil engineering programs, attract a greater share of civil engineering graduates, relax their certification procedures so that professionals from other fields can contribute more easily to their programs, or otherwise restructure their recruitment, training, and compensation policies to ensure that the necessary skills are available. Five steps appear particularly promising in meeting future needs:

- Revamping programs to train mid-level and management engineers to assume the varied responsibilities of retiring professionals (this may require revision of other procedures, such as relocation assistance, to facilitate the accelerated development of in-house professionals);
- Shifting the mix of professional specialties hired. Future program needs and public expectations require greater expertise in nonengineering fields, and the coming decade offers an opportunity to broaden the professional ranks to meet these challenges;
- Using consultants to meet selected skill requirements, such as for specialized engineering skills that are required only occasionally and for which full-time permanent professional staffs may not be the most efficient source;
- Making greater use of technicians, particularly as advances in data processing and other technological improvements create more routine solutions to some of the problems that now require senior engineering judgment; and
- Exploiting the potential of computers through greater reliance on computer-aided design and drafting, automated pavement and maintenance management systems, and other applications.

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Part II Workshop Reports

Transportation Engineers for Local, State, and Federal Government

DEMAND ISSUES

The paper by Larson and Haack provided an excellent framework for the workshop deliberations. A central theme was the recognition that for the foreseeable future, transportation engineering professionals will be more involved in the management of transportation systems than in the development of such systems, which has been the principal focus over the last several decades. The emphasis on systems management includes pavement maintenance, rehabilitation, and overall perpetuation of the street, highway, and transit infrastructure. There are, however, other significant items of paramount importance that will affect the knowledge and skills required of tomorrow's transportation engineering professionals. These items include the following:

- Systems management;
- Private contractors;
- Computers;
- Specializations needed;
- Flexible organizational structure;
- Retirement of experienced engineers;
- More diversified challenges;
- Increased coordination at all levels of government;
- More global interest;
- Legal, institutional, regulatory, and financing issues and shifts; and
- Interest of students in transportation.

Systems Management

As discussed previously, with the shift from systems development to systems management, it is recognized that skills that would enhance an individual's ability in pavement management, for example, will be mandatory for the professional transportation engineer. Systems management or value engineering, as one participant suggested, also includes the ability to enhance the operational level of service as well as service quality through minimum or nominal adjustments in the existing infrastructure. It is recognized that the emphasis will be on perpetuating the transportation infrastructure that currently exists with a secondary emphasis on development of improvements and additions. This shift suggests a number of knowledge requirements and additional skills needed beyond those currently provided in the traditional engineering program.

Private Contractors

The use of private consultants and contractors by all governmental levels to augment their professional staffs is a trend that will continue. Therefore, transportation engineers at all government levels need to be aware of the administrative and management skills necessary to maximize the private-public relationship. In addition, there is concern that the trend toward private consultants and contractors will negate the responsibility of government to have professional transportation engineers with the needed expertise in high technical areas. It is recognized that this is a grave concern and that government should not rely completely on external expertise, but should retain and, indeed, provide for the development of needed advanced skills and knowledge within its ranks.

Computers

The use of computer-aided design/computer-aided manufacturing (CAD/CAM) systems and personal computers will continue to grow at increasing rates. Therefore, individuals entering the profession will need to be at ease with basic programming as well as with the use of packaged software.

Specializations Needed

Although it is recognized that current trends emphasize the need for a broader, more diversified educational foundation, it is also critical that there be an engineering education base from which advanced education leading to high specification skills can be achieved for otherwise qualified individuals. It is through specialization that technological advances are made; therefore, it is imperative to stress the critical importance of fostering specialization and the role of government as the catalyst in this endeavor.

Flexible Organizational Structure

In addition to the shift toward systems management and private consultants, the organizational structure of the traditional transportation organizations at all government levels has changed in the last decade and is likely to experience additional changes in the future. Realizing this phenomenon, it is recognized that administrators of these transportation organizations require an organizational structure that is flexible enough to address their organizational goals and objectives while providing for horizontal and vertical mobility of their professionals.

Retirement of Experienced Engineers

A common characteristic of most of the traditional transportation organizations that existed and expanded during the 1950s and 1960s is that those engineers that entered the profession during this era of the system's development are reaching retirement age. This maturing professional workforce will be retiring during the next decade and will be leaving a significant void of experience while offering opportunities for the new professional. These challenges and opportunities need to be highlighted in the recruitment of new professionals.

More Diversified Challenges

It was emphasized during the workshop discussions that the challenges and opportunities that face the new transportation engineer are some of the most interesting and potentially rewarding that have ever occurred in the profession.

Increased Coordination at All Levels of Government

The changing responsibilities of governmental organizations require more involved coordination activities. A new transportation engineering professional will need additional skills that enhance this relationship.

More Global Interest

The role of international activities in the day-to-day mission of transportation organizations is extremely important. The examples of the Organization of Petroleum Exporting Countries (OPEC), manufacturing of transit vehicles, and other similar instances, stress the importance of an awareness and appreciation of intergovernmental as well as international relationships.

Legal, Institutional, Regulatory, and Financing Issues and Shifts

In addition to the technical expertise and the management skills required of the new professional, the legal, institutional, regulatory, and financing issues cannot be ignored. The effect of recent government enactments, such as modal deregulation, require that the new professional be equipped to assess the changes and impacts of these activities. Although the new engineering professional cannot be expected to have expertise in all of these areas, a sensitivity to and an awareness of the issues and their effects is paramount.

Interest of Students in Transportation

Concern was expressed that the opportunities that are readily apparent to those in the profession today are not recognized or appreciated by the young professionals or students in the universities. The concern included the image or perception of transportation as a profession. A challenge was made to today's transportation engineer to participate more fully in student as well as community affairs.

The discussion of trends enabled workshop participants to concentrate on the knowledge and skills required of the transportation engineering professional to enable him or her to better meet future challenges. The knowledge and skills required of transportation engineering professionals are discussed next.

Broad Educational Foundation

In addition to the traditional undergraduate engineering program offered at universities, it was emphasized that further broadening beyond this program is needed. The broadening educational objectives should include further courses in management, public policy, and administration to include personnel administration, economic theory and concepts, and law. Although discussed more fully in the Supply Workshop, it was recognized that a number of options exist excluding degree programs that may satisfy this need.

Specialization

It was emphasized that although a broadening undergraduate educational base is necessary to enable the professional to deal effectively with future challenges, this base should include the ability of an individual to seek and to achieve specialization in numerous technical areas. Graduate education, or in some cases, advanced training, may be the best means of facilitating this requirement. The undergraduate education should not preclude or hinder the development of professionals who, through research, development, and innovative practices, will create the technology and techniques needed to solve many of the transportation problems and issues.

Communication

Communication skills required of the future professional may be even more important in the future than they are today. One of the glaring weaknesses of the engineering professional continues to be his or her preparation in both oral and written communication skills. More emphasis may be needed at the undergraduate level.

Computer

A basic appreciation of and familiarity with computer hardware and software will be essential for professional survival. Although extensive programming skills may not be required for all professionals, the ability to interact and to be at ease with current computer systems is an absolute necessity.

Group Dynamics

Equally important as the communication skills stressed earlier is an appreciation and familiarity with group dynamics, which will prove to be an important asset for the engineering professional. This need is certainly recognized as essential today, and it is believed that an enhanced ability to effectively work with multidisciplinary teams, public groups, and decision-making groups, such as legislative bodies or local elected councils, will be an asset to transportation programming and implementation in the future.

Global Perspective

As discussed earlier, an awareness and appreciation of events that are occurring outside our jurisdiction or immediate area of responsibility, whether it be in the next city, county, state, or in another nation, can be critical to effective programming and implementation.

Energy and Environmental Awareness

Workshop participants stressed that an appreciation for energy and environmental issues will continue to be an important aspect of an effective transportation system or program. Therefore, a basic knowledge of both of these areas will enhance job performance.

Research Appreciation

Because research offers hope for the future, it is believed that all individuals in the transportation profession should be aware of research activities that may have an impact on their field. There are numerous forums for achieving this objective; however, a basic appreciation of research and development (R&D) should be instilled not only as part of the formal undergraduate educational program, but also as an ongoing activity throughout a transportation professional's career.

In conclusion, it is believed that the field of transportation is a very broad one and requires a diversity of skills. Not all requirements can be met within a single educational institution. Various programs may offer specializations in one or more areas such as public transportation, highway design, and economic analysis; however, it is unlikely that advanced expertise could or should be available at each and every institution offering a transportation program. A broad educational foundation is needed by most, if not all, transportation professionals. The opportunities available to the transportation professional offer a rich array of outstanding and exciting challenges. It is the responsibility of the current professional transportation corps to better inform and educate others about these opportunities.

SUPPLY ISSUES

The first session of the workshop, which considered demand issues, dealt with current and future trends in the transportation engineering field, and participants assessed the emerging educational needs for transportation engineering professionals for local, state, and federal agencies. In the second session of the workshop participants considered the supply side of the problem. In other words, efforts were made to identify programs and strategies needed to meet the types of educational needs determined in the first session.

Stages in Professional Development

It was recognized that education and training needs will depend on the stage of a transportation engineer's career path. The requirements for an entry-level professional will be different from those at the mid-management level, and so on. For the purpose of identifying the specific types of programs, the possible stages in the career path of a transportation engineer in a government agency were delineated. These stages can be termed as entry level, trainee or intern level, professional level, and specialist or management level. An entry-level transportation engineer would be primarily drawn from undergraduate civil engineering programs. Some of these entry-level engineers would already have been exposed to some of the activities of an agency through participation in a cooperative employment program during their undergraduate years.

The first 3 to 5 years of employment in an agency can be considered a period of traineeship or internship when an individual receives overall experience in one or more functions of an agency. The comprehensiveness of this experience will obviously depend on the type of agency. For example, although it may be possible for a beginning engineer to become involved in all aspects of an agency's activities in a county highway department with a small number of technical employees, in a state highway department a beginning engineer may have an opportunity to work closely with only a few divisions, such as design or traffic. However, some state highway and transportation departments have an organized training program to rotate beginning employees or trainees through all major divisions during an initial period.

The next stage in a transportation engineer's career path can be termed the professional level. This stage can be between 5 and 10 years after employment in an agency when an employee advances in his or her career and chooses either to become primarily a specialist or to move into a management position. For example, in some state highway departments there are positions for specialists, such as soils engineer, bridge design engineer, and so forth, in addition to the management positions of resident engineer or district engineer.

The last phase in the career path is considered the position of senior professional, either as a specialist or as a manager. This level would also include top management such as director or deputy director. It is recognized, however, that in most local transportation agencies some distinction exists between specialists and managers, because in these agencies the task of top management may also include that of a specialist.

The possible education and training needs at each of the levels identified are shown in Figure 1. At the entry level, an accredited baccalaureate degree in engineering is assumed. Any engineering program accredited by the Accreditation Board for Engineering and Technology (ABET) will have the minimum humanities and liberal arts requirements along with appropriate courses in physical and mathematical sciences, in addition to core and optional engineering course requirements. However, those students who want to make transportation engineering a career must acquire appropriate computation skill using both a mainframe and a microcomputer. They must take a two-course sequence in macro- and micro-economics and must develop basic oral and written communication skills. Both the computation and communication skills can be provided through the existing curriculum by requiring students to use the computer and to write and present technical reports in class.

Basic management skills also need early attention. Transportation engineering students should be encouraged to take basic management courses if the schedule permits. Basic management skills can also be developed by taking active part in the leadership of student chapters of various professional societies. It is recognized, however, that there is no substitute for a solid background in basic science and engineering. In this regard, it is necessary to point out that although knowledge in some specific aspects of transportation engineering is necessary, it is not essential for an entry-level position to be conversed with all aspects of planning, design, construction, and operation of transportation facilities. Some of this knowledge can be acquired on the job as well as through graduate study during the early period of a career. Furthermore, workshop participants strongly believed that a successful transportation engineering professional must have an appreciation for research, and such an appreciation can best be acquired through actual research experience at an early stage. Transportation engineering students should be exposed to systematic research even at an undergraduate level.

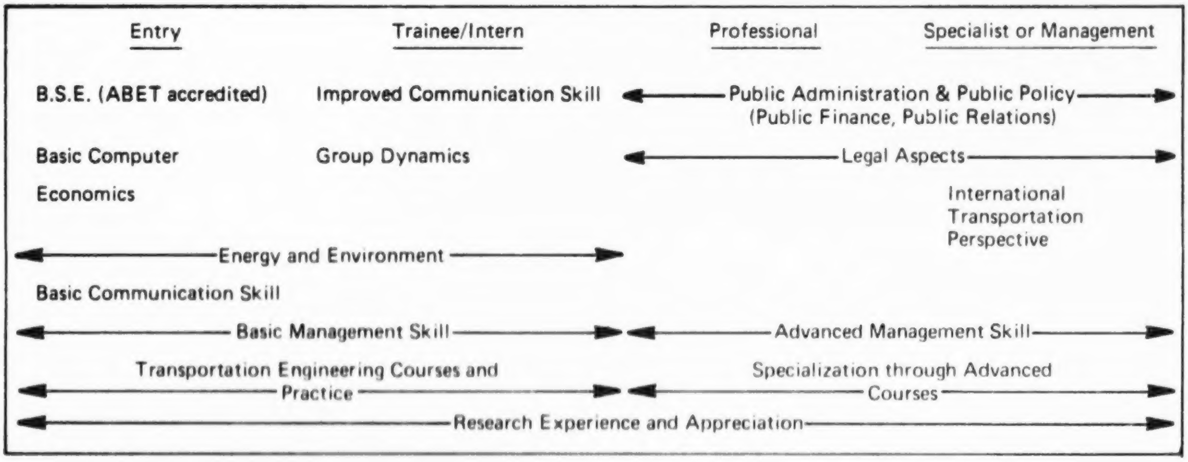
Entry
Trainee/Intern
Professional
Specialist or Management
B.S.E. (ABET accredited)
Improved Communication Skill
Public Administration & Public Policy
(Public Finance, Public Relations)
Basic Computer
Group Dynamics
Legal Aspects
Economics
International Transportation Perspective
Energy and Environment
Basic Communication Skill
Basic Management Skill
Advanced Management Skill
Transportation Engineering Courses and Practice
Specialization through Advanced Courses
Research Experience and Appreciation

FIGURE 1 Types of skill and knowledge necessary at various stages of a transportation engineer's professional development.

During the training or internship period, a transportation engineer should be provided the opportunity to improve both oral and written communication skills as well as basic management skills. The engineer should also have the opportunity to learn group dynamics primarily by being a part of multidisciplinary working teams involved in public hearings as well as interacting with the public in general. The training period is also important in acquiring knowledge in transportation engineering and in practical aspects of transportation. This is particularly important to those who did not take sufficient courses in transportation in their undergraduate program. In addition, the appropriate opportunity to be involved in research is also necessary for engineers during their beginning years. At the same time, transportation engineers should be provided the opportunity to develop an appreciation for energy and environmental issues during their training period, and this opportunity should be extended through the professional period.

During the professional period covering 5 to 10 years of employment, most engineers will choose either a management path or a path leading to a specialist's position in the agency. The necessary education and training needs during this period will, thus, depend on the intended career path. In general, those choosing the career of a specialist will need to acquire advanced knowledge in particular fields of their choice, such as soils, pavement or bridge design, highway materials, and so forth. On the other hand, those in mid-management positions will need a broad knowledge of public administration and public policy, particularly in the area of public finance and budgeting. Individuals at this level of professional development must also be familiar with various legal aspects of agency activities. In addition, these individuals should acquire advanced management skills to supervise professionals and technicians with diverse backgrounds.

As shown in Figure 1, the training and education needs at the professional level and beyond are basically similar in nature. Some individuals who have been employed 15 to 20 years would be close to the top of the career pyramid either as a specialist or as a manager. Beyond that level some would progress to the top management level. At this level, ability is needed to deal with the legislative bodies in particular and the public in general. Another important attribute necessary at the top management or specialist level is the development of an international perspective. Specialists should be aware of recent technological developments abroad for possible application, whereas those at the top management level should develop a global interest to the extent that international, economic, and political developments may affect the activities of the agency.

TYPES OF PROGRAMS

An effort was made to identify the types of programs and opportunities required to provide appropriate education and training to transportation engineers at various stages of their professional development in federal, state, and local agencies. Given in Table 1 are the possible sources that are either currently available or can be made available in the future to provide employees the opportunity to improve their education and training.

The sources for acquiring the necessary education and training beyond an entry-level position may include a graduate degree program, continuing education courses and workshops, in-house training programs, and meetings of professional societies. State and local agencies, in cooperation with appropriate federal transportation agencies, can offer relevant continuing education courses on a regular basis. The Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) have made a considerable effort in preparing the necessary instructional materials on certain subjects. These materials are available to a wide range of organizations. Efforts are also being made by the various University Technology Transfer Centers sponsored by the FHWA and state transportation agencies in cooperation with universities to disseminate information, particularly among local transportation agencies. Employees should be given adequate opportunity and encouragement to take advantage of these workshops. In addition, employees should be given appropriate incentives to keep abreast of the profession by the provision of tuition free credit, job advancement, or a salary increase on completion of a graduate degree program. Employees should also be encouraged to take an active part in the activities of various professional societies both at the local and national levels. Attendance at technical meetings can greatly assist employees in keeping up-to-date in the field.

As indicated in Table 1, there are alternative sources of the necessary knowledge and skill in most cases. For example, transportation engineering and practice can be provided through continuing education, degree programs, and in-house training programs, if available. It is important to point out that a cooperative effort between transportation agencies and local universities may be mutually beneficial in organizing various aspects of education and training programs for employees on a continuing basis.

TABLE 1 Types of Programs Required to Provide Necessary Knowledge and Skills

Types of Knowledge and Skill	Program
Basic social science and humanities (including economics)	Undergraduate degree program
Basic physical science and mathematics	
Basic communication and management	
Computer	
Improved communication	In-house training, continuing education, professional meetings
Group dynamics	
Management	
Transportation engineering and practice	Continuing education, degree program, in-house training
Public administration and public policy	Continuing education, degree program
Legal aspects	Continuing education
Energy and environmental awareness	Continuing education, degree program, in-house training
Specialized courses	Continuing education, degree program
Research experience and appreciation	In-house training, degree program, professional meetings

RECOMMENDATIONS

Workshop participants made the following recommendations:

1. Some minimum level of continuing education should be specified for transportation engineers as determined by some recognized national organization as a prerequisite for professional advancement. A transportation agency at any level of government should have a clear and defined policy regarding the education and training needs necessary for a particular stage of advancement.
2. Opportunity for professional development is essential for employees' motivation and morale, as well as for agencies' progress. It is therefore necessary that the employers consider it their responsibility to provide for employees' in-house training, continuing education, and other means that will enable employees to enhance their skills and knowledge and advance in their career.
3. Employees should be appropriately rewarded and recognized for their initiative and effort in undertaking advanced degree programs.
4. Employees should be encouraged to participate in professional society activities, including attendance at local and national technical meetings. Transportation agencies should provide appropriate incentives in this regard.

5. Educational institutions should review and update their transportation engineering curriculum periodically to ensure that it fulfills the changing professional requirements.

6. Educational institutions should make efforts to develop and strengthen transportation faculty and related facilities. Faculty members should be strongly encouraged to retrain themselves through sabbaticals and other programs.

7. There is a need for a sustained level of basic and cooperative research funding in transportation. Although transportation agencies at all levels of government should be responsible for securing such funds, it is absolutely essential that the federal government take the leadership.

8. Efforts should be made to interact and collaborate through various university, industry, and government programs to meet some of the education and training needs in transportation engineering.

9. Efforts should be made to implement some of the foregoing recommendations through a cooperative effort of the American Association of State Highway and Transportation Officials (AASHTO), American Public Transit Association (APTA), and other appropriate organizations.

Transportation Planners and Demand by Government Agencies and Their Consultants

In this workshop both the demand for transportation planners and the education and training problems associated with meeting that demand are addressed. Although it is difficult to summarize two days of wide-ranging discussion, several key conclusions emerged from the workshop:

1. Fewer people are entering the transportation planning field today than in the past. Whether this is because of perceived decreased opportunities or lower salary potential is uncertain, but it may be for both reasons.
2. Most of today's transportation planners were trained during the 1960s and 1970s. Thus, the field is not likely to be seriously affected by retirements for the next few years.
3. Despite declining enrollments, there does not appear to be a serious shortage of entry-level transportation planners at present, but demand is also relatively low.
4. Transportation planners now entering the job market need expanded and improved skills, particularly improved communication skills, a better grounding in quantitative and analytical skills, and improved problem-solving ability.
5. The declining enrollment in civil engineering, from which transportation planning draws most of its professionals, could pose a serious problem in the future, if the national pendulum swings toward more emphasis on transportation planning to replace a deteriorating transportation infrastructure. Problems are sensed in rigid university curricula, a deteriorating university plant, low morale in the teaching corps, and other problems within the educational structure that could weaken our ability to respond to increased engineering and transportation planning needs in the future.
6. Many traditional engineering agencies have employee classification structures that do not allow planners entry or upward mobility within the agency. Agency heads, especially at the state level, should be encouraged to assess their personnel systems and develop career patterns for nonengineering professionals.
7. There is a need for the public sector to reaffirm its commitment to university research that can support stronger transportation planning educational programs. There is a corresponding need for greater involvement of the private sector through increasing work-study opportunities in the nonacademic world for both students and university faculty.

The remainder of the workshop summary included a description of the likely demand for transportation planners in the future by various levels of government and their consultants, identification of the skills that will be needed by transportation planners, and a discussion of the problems involved in providing these skills through education and training.

FUTURE DEMAND FOR TRANSPORTATION PLANNERS

In the paper titled "Transportation Education: University Degree Programs" elsewhere in this report, Biemborn noted that the engineers and planners being educated in universities today will spend most of their careers working in the 21st century. The workshop participants found it difficult to speculate on the changing conditions that could affect transportation planning over the next 10 to 20 years. Thus, the following estimate of demand for future transportation planners should be reasonably reliable over the next 5 years but uncertain beyond that period. This uncertainty underscores the need for continuing education to provide transportation planners the special training they may need to face new developments in the field.

Demand by the Federal Government

Transportation planners within federal agencies such as the Urban Mass Transportation Administration and the Federal Highway Administration have declined in number in recent years, and this decline is likely to continue. The transportation planning staff within federal agencies is fairly young and few retirees are expected within the next 5 to 10 years.

Some of the characteristics of federal agency demand for transportation planners are:

1. Federal Highway Administration field offices tend to want engineers and planners whose engineering background could be of more direct benefit during emergency situations (i.e., bridge failures and other disaster situations).
2. Professionals working on the policy side of federal agencies are likely to be nonengineers, whereas those related to the program side are more likely to be engineers.
3. Federal agencies are very active in upgrading staff skills through continuing education.
4. Federal employment trends are toward further decentralization (i.e., more personnel in field offices versus in Washington) and generally limited hiring opportunities overall.

In summary, the federal government is not likely to have a major demand for transportation planners in the foreseeable future, regardless of the political administration in power. Moreover, the number of people involved is so small as to be relatively inconsequential in terms of overall need for transportation planners.

Demand by State Government

Following the principle of decentralization of responsibility from the federal government to lower levels of government, the demand for transportation planners is likely to be somewhat greater at the state level than at the federal level, but with a different focus than the demand has been in the past. The national emphasis on rehabilitation of the transportation network will create new staffing requirements that can draw on transportation and system planning skills. Areas such as maintenance and bridge rehabilitation can use transportation planning skills for programming, assigning of priorities, and projection of needs. Workshop participants believed that there were opportunities to apply transportation planning skills and principles to a host of maintenance and improvement needs, such as pavement management systems.

Much of the traditional transportation systems planning work has been decentralized from the state level and delegated to metropolitan planning organizations (MPOs) and local communities. This could mean that state employees who have traditionally performed this type of systems planning in the past may need to take advantage of the opportunities mentioned earlier in maintenance and improvement programming.

Several workshop participants noted a significant institutional and cultural problem facing transportation planners in most state transportation agencies. The problem is that many old line engineers do not accept transportation planning skills as being applicable to the problems they face in their sections. This has been a problem for many years, and as traditional transportation planning work decreases within state transportation departments, it could become increasingly difficult for planners to shift to other activities within the departments.

The outlook for transportation planners in state governments is reasonably good. Nevertheless, to capture the opportunities, planners will have to apply their skills to new areas of maintenance and rehabilitation, and old barriers between engineers and planners will have to be overcome.

Demand by Local and Regional Government

As noted earlier, the decentralization of transportation planning responsibilities has resulted in the development of strong planning staffs within MPOs, transit authorities, and other local and regional agencies. The demand for transportation planners should remain relatively strong at the local and regional levels, but new planners should desirably be equipped with stronger skills for dealing with citizens and community groups, as well as the private sector. Local and regional transportation planners must have a strong orientation to the implementation process. They must be adept in finding innovative ways to stretch limited transportation financial resources. An entrepreneurial spirit will be a valuable trait for future transportation planners in local government.

Demand by Consultants

To some extent, the demand by the consulting industry parallels that of public agencies discussed earlier in terms of an overall future demand that will be somewhat less than what it has been in the past. One of the principal factors that will affect the demand by consultants for transportation planners will be the extent to which state transportation agencies make policy decisions to constrain their staff size and to rely on contracting with the private sector. Several states are already moving in this direction, and thus, the demand for consultant services (and the market for transportation planners) could vary significantly from one part of the country to another. Consultants may also offer a greater opportunity for transportation planners to shift into new and related areas if there is a decline in the traditional markets for transportation planning skills.

FUTURE EDUCATIONAL NEEDS FOR TRANSPORTATION PLANNERS

There was general agreement among the workshop participants that improvements are needed in the university education and on-the-job training of transportation planners. Improved skills are needed in at least the following three major areas:

1. Communication,
2. Quantitative and analytic methods, and
3. Strategic thinking.

A better definition of the specific skills in each of these areas is provided in the following sections along with a discussion of some of the problems that may be involved in providing these skills.

Communications Skills

Participants in all of the workshops underscored the need for improved communication skills by the particular group with which they were concerned. Specifically, improved communication skills are needed for transportation planners in the following areas:

1. Consensus building and mediation. The increasing involvement of transportation planners with the implementation process is bringing them into closer contact with elected officials and citizens groups in situations that require a consensus or decision on a particular action. It is not enough for transportation planners to provide technical information in such cases. They must execute the planning process and help to create an environment in which consensus can be reached and decisions can be made. This requires expertise in dealing with groups and individuals that is not typically gained through present transportation planning curricula.

2. Interpreting complex problems and solutions in simple language and graphics. Transportation engineers and planners have always had the problem of communicating the results of their analyses to people with nontechnical backgrounds, and this problem is as great today as it has ever been.

3. Group dynamics. This area is closely related to consensus building and mediation. Transportation planners need a better understanding of group dynamics and how to deal with multiple and usually conflicting views within a group setting, whether it be a citizens group, a local governing body, or a staff or multidisciplinary team.

4. Basic writing and oral communication skills. Most graduating transportation planners are not well equipped with basic writing and oral communication skills, and it is difficult to acquire a basic knowledge in these skills after leaving the university environment. Employers have little tolerance for the need to learn basic writing and speaking skills on the job.

Some of the possible approaches to improving and providing these communication skills for transportation planners are:

1. Strengthen undergraduate English courses with an emphasis on grammar and composition.
2. Possibly provide an editor for student technical papers. The editor would be responsible for reviewing grammar, sentence structure, organization, and other composition issues, whereas content would be evaluated by the regular course instructor or professor.
3. Increase class attendance at public hearings, city council meetings, and community meetings. Students would have an opportunity to observe the process of consensus building and mediation in such groups and to gain a greater appreciation of group dynamics as exercised in a real-world setting.
4. Provide special courses in group dynamics, oral communication, and technical writing. There is a need in most universities to provide special courses to improve these skills beyond what is currently available in undergraduate English or humanities courses typically included as part of the curricula for transportation planners.

There are significant problems in implementing these actions. For example, there is apparently little room in present engineering and transportation planning curricula for new courses such as those mentioned previously. Similarly, time for outside activities, such as attending public meetings and participating in outside class projects, is also limited for both students and faculty. Increased use of practical problems and free consulting will place increased time requirements on university staff, who may already be overloaded by overall teaching and research requirements.

Quantitative and Analytic Skills

An important consensus of the workshop was the need to strengthen the typical civil engineering and transportation planning background with stronger quantitative and analytic skills in one or more of several related skill areas such as:

1. Transportation economics,
2. Finance,
3. Statistics,
4. Mathematics,
5. Operations research,
6. System analysis, and
7. Urban design.

A stronger background in these areas will improve transportation planners' ability to apply a rigorous, analytical approach to problems, as well as provide them special skills that are likely to be increasingly important in the future (i.e., in finance and economics). Although urban design might not be considered a quantitative skill, workshop participants believed that it will be important to transportation planners in the future because they have to deal with microscale project implementation within the urban environment.

Computer literacy was also considered to be essential for transportation planners because of the growing importance of microcomputers in the field. Computer literacy means sufficient familiarity with microcomputers to be able to use the wide variety of canned software available within the field today and sufficient basic programming skills to fully understand the potential application of these software packages.

All of the quantitative and analytic skill areas mentioned previously are currently available at most universities that are producing transportation planning graduates. One problem in providing these skills is, again, the already crowded curricula for most civil engineers and transportation planners, which leave little space for additional courses. A second problem is that many of these courses are offered in other university departments and may not be available to transportation planners. Finally, there are often insufficient microcomputers and relevant software for students to use in most universities.

Strategic Thinking Skills

Workshop participants had difficulty labeling several skills that are considered to be very important for transportation planners and finally agreed on the term strategic thinking as best defining these skills. Basically, strategic thinking skills are highly related to the implementation process and to problem solving that reflects an understanding of the respective roles of the public and private sectors. Specifically, strategic thinking skills have the following characteristics:

1. The ability to identify essentials and solve problems.
2. An understanding of government structure and the public decision-making process.
3. The ability to "package" recommended solutions to achieve greater cumulative benefits than would be possible through individual, noncoordinated actions.
4. A sense of the value of timing in packaging and pushing recommendations. This skill is strongly related to an understanding of government structure and the decision-making process through which the transportation planner can gain a better appreciation of how his or her work might influence that process.
5. An ability to maximize public and private cooperation to gain the greatest possible benefit from limited public resources through greater cooperation with the private sector.
6. An entrepreneurial mind-set that makes the transportation planner increasingly results-oriented and more willing to consider innovative and self-supporting approaches to meet transportation requirements.

Clearly, these skills are difficult to teach. During one of the conference plenary sessions, Thomas Larson, Secretary, Pennsylvania Department of Transportation remarked that as much as 80 percent of the knowledge required to perform strategic management in transportation comes from on-the-job experience. Nevertheless, young transportation planners can bring sharpened basic skills in these areas to the profession through

1. Involvement in more meaningful, relevant research that challenges their ability to conceptualize solutions to problems and to develop a strategy for implementing those solutions.
2. Training in public administration and political science that would provide them a better understanding of the planning and decision-making process.

3. Greater exposure to the planning and decision-making processes through practical problems, outside speakers, attendance at public meetings, and case studies of transportation projects that illustrate the application of strategic thinking skills.

Some of the problems in acquiring these skills include the issue of crowded curricula mentioned earlier as well as the difficulty in teaching such skills. University staff need more outside, practical experience in order to be able to effectively impart strategic thinking skills to their students. Workshop participants observed that most university research does not go nearly as far as needed in developing these skills.

Operations and Management Personnel for Transit Companies

TRENDS THAT HAVE A SIGNIFICANT IMPACT ON THE TRANSIT INDUSTRY

Workshop participants considered a wide range of social, economic, and demographic trends, as well as trends within the transit industry. The following 13 trends are considered to have a significant impact on the education and training of transit professionals:

1. Limited resources (financial, energy, and human);
2. Computerization;
3. Introduction of new technology;
4. Deferred maintenance of capital equipment and plant;
5. Changing product market;
6. Changing workforce (composition, values, skills);
7. Declining esteem of public service;
8. Institutional blockages to recruiting (civil service and work rule);
9. Job specialization and professionalization;
10. Increasing public exposure and accountability;
11. Poor industrial relations climate;
12. Increasing private sector involvement (service delivery, financing); and
13. Increasing state and local involvement.

Six trends considered noteworthy but insignificant so far as the education and training of professionals are:

1. Deregulation,
2. Energy supply changes,
3. Increasing number of foreign manufacturers,
4. Increasing number of foreign students,
5. Lagging basic research, and
6. Declining elementary and high school achievement scores.

POSITIONS OF CONCERN

Workshop participants focused their deliberations on three levels of positions in mass transit organizations:

1. Managers,

2. Operations staff (staff specialists, technicians), and
3. Line supervisors.

Excluded were nonmanagers (bus operators and mechanics) and policy board members.

Required Skills and Desired Skills

For these three groups a mix of 15 skills is required and desired:

1. Adaptability,
2. Creativity,
3. Leadership,
4. Political sensitivity,
5. Communications,
6. Interpersonal,
7. Personnel management,
8. Organizational behavior,
9. Analysis (quantitative),
10. Problem solving (strategic thinking),
11. Computer management and use,
12. Transportation planning,
13. Marketing and public affairs,
14. Budgeting, and
15. Project management.

Although personal attributes, such as intelligence and charisma, were considered desirable, they are not included because they cannot be taught and learned.

In addition to specific skills (many of which are not uniquely transportation-related), managers, operations staff, and line supervisors also need to understand transit system operations and possess certain technical skills as appropriate to specific jobs.

Managers should possess all skills, preferably when they are hired. Operations staff members should possess interpersonal, creative, and analytic skills and the appropriate technical specialities related to their positions. Line supervisors should possess problem-solving, industrial relations, and public relations skills and be thoroughly knowledgeable of system operations.

DELIVERY MECHANISMS FOR EDUCATION AND TRAINING

Individuals might acquire skills through undergraduate and graduate education at colleges and universities; by acquiring certificates from colleges, universities, or technical schools; by completing continuing education courses offered by educational institutions, professional organizations or government agencies; by participating in in-house training courses; and through on-the-job training opportunities, including skills enhancement courses, job rotations or exchanges, and regular performance evaluations.

How the education and training is acquired is not so important as whether it is (a) readily available, (b) consistent with a personalized training needs assessment, or (c) rewarded by opportunities for recognition or advancement. Although training programs should be tailored to meet individual needs identified through a training needs assessment, all programs should address the special training needs that result from the traditional industry practice of promoting line supervisors up-through-the-ranks, instead of hiring top managers from outside. Specifically, line supervisors are likely to need courses in management, whereas managers are likely to need exposure to system operations.

PROBLEMS ENCOUNTERED IN ATTRACTING QUALIFIED CANDIDATES

Four problems encountered in attracting qualified candidates were identified:

1. The transit "employee pool" encompasses diverse skills and backgrounds that complicate the recruiting process. At the same time, industry needs are unclear because of major environmental changes.
2. There is a shortage of people with particular skills, such as maintenance supervisors and computer technicians. Few professionals entering the industry are knowledgeable of transit system operations.
3. Industry personnel offices are often understaffed, and those working in personnel may lack training in modern techniques and may also be expected to conduct labor relations, which leaves little time to develop and implement effective recruiting and training programs.
4. Position specifications often reflect past hiring practices rather than true needs; the result is that the applicant pool is limited to applicants with specific technical educations when, in fact, the position might be effectively filled by applicants who possess no particular technical skills; for example, many traditionally engineering jobs might be filled by nonengineers.

PROBLEMS ENCOUNTERED IN EDUCATING AND TRAINING QUALIFIED PROFESSIONALS

Problems encountered in educating and training qualified professionals were identified:

1. There is no clear statement of the need for education and training in that the industry is undergoing major changes and has not articulated a vision of the future.
2. There is a history of adversary labor-management relations that may result in union resistance to management-sponsored training programs for employees who are represented by a union.
3. Transit industry decision makers tend to undervalue education and training as a means to improve productivity. As a result, they may limit funding and staff support for programs, or they may fail to reward program participants.
4. There is a tendency by educational institutions to narrow the curriculum in a way that restricts employment opportunities for graduates, making enrollment less attractive. Institutions, administrators, and faculty also tend to design programs in response to opportunities for outside financial support so that needed education and training may not be available if outside support is withdrawn.
5. Educational institutions are plagued by problems involving deterioration of physical facilities and outmoded equipment.

CONCLUSIONS AND RECOMMENDATIONS

One theme underlies all other workshop conclusions and recommendations. Contrary to preliminary indications of the Transportation Professional Needs Study (1), the crisis in transit has not passed. Instead the industry faces major problems in generating financial and political support and in effective human resources development, including educating, recruiting, and training qualified personnel. These problems are exacerbated by the fact that the industry continues to be in the process of transition, first from private- to public-sector management, and now toward delegation of certain aspects of service delivery and financing to the private sector. These pressures of limited resources and constant changes are a major cause of the industry's failure to clearly define its future roles or service delivery mechanisms. Without such a clear vision of the future, it is extremely difficult to identify longer range education and training requirements.

It is recommended that a human resource needs assessment and strategic management plan be developed for the industry. This human resource strategic plan would build on the Transportation Professional Needs Study (1) conducted by TRB with the cooperation of the American Public Transit Association (APTA). It would go beyond straight-line projection of needs to assess institutional and service-delivery changes and possible job position specification changes as a basis for identifying needed education, recruiting, and training activities. This assessment would also develop a methodology for evaluating the impact of education and training on productivity and suggest a cost-benefit value attributed to investments in human resources development. Having established such a value, the assessment should also explore the feasibility of and method for providing a fixed amount of federal and state funding for human resource development. For example, this might be in the form of a requirement that a fixed percentage of all federal capital funds be devoted to education and training programs at each recipient agency or institution. This assessment should be conducted jointly by TRB and APTA, not one or the other, and should be federally funded.

It is further recommended that a "handbook of best practices" be developed in which a comprehensive human resource development program is described, case studies of effective programs are provided, and "how-to-do-it" examples of specific activities are included. This handbook should be developed by a human resource development expert (consultant, professor, practitioner) who has extensive practical experience in the field. It should be guided by a committee of industry representatives who are actively involved in its development, and it should receive federal funding support.

After such a handbook is developed, a formal technology transfer program to ensure implementation of best practices should be sponsored. This might include workshops, expert consultations, networks, demonstration projects, or other means of exchanging ideas. This program might be sponsored by the federal government or a consortium of state and local agencies. (State agencies might develop packages for smaller agencies as well as sponsor state-wide programs.)

Universities and colleges should be encouraged to examine the adequacy of their current plant and equipment and faculty resources to provide effective education and training through degree or certificate programs or continuing education. Where appropriate, changes should be made to the faculty reward structure so that involvement in meeting industry needs is encouraged. This evaluation should be conducted by individual educational institutions that want to provide transportation education and training.

Also with regard to colleges and universities, it is recommended that the 1976 Directory of Courses and Curriculum be updated. After it is updated, it should be shared with the industry so that joint industry-educational institution education and training priorities might be identified on a regular basis. UMTA should sponsor this effort.

When courses and curricula are identified as priorities, but are unavailable, it is recommended that federal and state support be provided.

The federal government should continue to support college and university programs that will strengthen the representation of women and minorities in transit management, including support for historically black colleges and universities and programs at other colleges and universities tailored for women and minorities. U.S. Department of Transportation officials should address the foregoing recommendations on a priority basis.

Finally, it is recommended that follow-up to this conference include a meeting of appropriate TRB and APTA committees with the goal of reviewing this report and developing implementation strategies and assignments for specific recommendations, especially those related to federal and state support. The TRB staff should arrange such a meeting.

REFERENCE

1. Transportation Professionals: Future Needs and Opportunities. Special Report 207. TRB, National Research Council, Washington, D.C., 1985.

Transportation Technicians: Who Are They and What Are Their Training Requirements?

WHO IS THE TRANSPORTATION TECHNICIAN?

It must be recognized from the beginning that the transportation technician is not limited to the civil engineering technician working for state highway agencies. Much of the printed material prepared to date concentrates on just this segment.

Transportation technicians exist and are being used in all transportation modes and are critical elements of the work force at all levels of government and industry. The TRB Transportation Professional Needs Study (1) indicates that a higher ratio of technicians to engineers exists at the local level than at the state level. The technician universe also extends across all the other workshop subject areas at this conference. It is important to remain cognizant of those groups affected who are not fully represented at this conference.

It is therefore necessary in the suggestions for improvement presented in the following paragraphs that such improvements be applicable across this entire spectrum of transportation technicians. How wide is this technician universe? How far from the engineer and transportation professional relationship can we stray in identifying education and training needs for the transportation technician?

Remember that the root word of "technician" is "technical." With this in mind, the following definition is presented. A technician is one who carries out in a responsible manner proven techniques as known to those who are technically expert in a particular technology, engineering, or science or those techniques especially prescribed by qualified or certified personnel. Performance as a technician requires the application of principles, methods, and techniques appropriate to an accepted technical or scientific field of study or discipline combined with practical knowledge of systems, processes, data collection, materials, devices, equipment, machinery, and, as required, related manual crafts and instrumental, mathematical, or graphic skills.

Under professional direction, the technician analyzes and solves technological problems, prepares formal reports on experiments, tests, and other projects, or carries out functions such as those associated with design, technical sales, consumer advice, technical writing, teaching, or training. The education of a technician places great emphasis on the applied sciences in combination with intensive laboratory training in which the technician develops practical knowledge and skills. Technicians differ from craftsmen in the extent of their knowledge of scientific and engineering theory and methods.

GENERIC PROCESSES

In consideration of the preceding discussion, it is essential that first consideration in the education and training of transportation technicians be given to identifying and using generic process approaches that can be viable for all the various subgroups in the technician population.

One appropriate model for such a process approach is the classification of technicians into levels from entry to senior level used by the National Institute for the Certification of Engineering Technicians (NICET). A matrix of these levels versus six requirement categories is used, as indicated in Table 1. The concept of the generic process will be applied through the remainder of this workshop summary.

TABLE 1 Summary of General Enrollment and Certification Requirements

Level	Minimum Full-Time Experience	Verification of Experience	Recommendation Requirements	Written Test Requirements	Form of Certification	Performance Capabilities
I	No minimum time requirement. Eligible when ability in required work elements is established.[a]	By supervising engineer(s) or job superintendent(s) who actually supervise candidate.	One from person familiar with candidate's work.	No written test.	Letter of enrollment provided. No certificate issued.	Entry level work under direct supervision.
II	At least 2 years total.	By supervising engineer(s) or other persons as specified in orientation manual.	Same as Level I	Written test covering work elements.[b]	Certification as Associate Engineering Technician (AET).	Intermediate-level work within specified field under general supervision.
III	At least 5 years total.	By supervising engineer(s) or other persons as specified in orientation manual.	Same as Level I	Written test covering work elements.[b]	Certification as Engineering Technician (ET).	Independent work with little or no supervision on jobs covered by standard and complete plans, specifications, or instructions.
IV	At least 10 years total plus significant involvement in one major project.[c]	By professional engineer or supervising engineer. Unusual job conditions may justify someone else. Refer to orientation manual.	At least one recommendation of character and interview may be required.	Written test covering work elements. Personal interview may be required.[b]	Certification as Senior Engineering Technician (SET).	Assistant to professional engineer or supervising engineer with authority to act in name of engineer in matters in which delegated and engineering precedent exists.

[a] Level I enrollment must be upgraded to Level II certification no later than 2 years after initial enrollment. If Level II certification is not sought, the Level I enrollment will be automatically terminated at the end of 2 years.

[b] Refer to the particular orientation manual for details of the examination requirements.

[c] This is a strict requirement and there will be no exceptions made.

HOW MANY TECHNICIANS?

How many transportation technicians are there currently, and how many will be needed in the coming years? These numbers are currently difficult to determine. Estimates of the number of highway technicians alone now range from 40,000 [TRB Transportation Professional Needs Study (1)] to 150,000 (National Highway Institute).

The only data on numbers of technicians based on actual surveys are for those employed by state highway departments (1). Extrapolating the numbers from this one group to determine the technician population in local agencies, private practice, and public transportation can result in misleading statistics and can do more harm than good.

For example, it was the consensus of workshop participants that there are even more technicians working on highways at the local level than at the state level, and that there is also a higher proportion of technicians to engineers at the local level. The numbers reported in the TRB Professional Needs Study (1) of 25,000 highway technicians in state agencies (by survey), and only 15,000 in local agencies (by extrapolation) is questioned.

There was no consensus on whether the number of transportation technicians needed in the future will be significantly greater than the number needed now. Although there was agreement that the technician's role is expanding, leading to an increase in the number required, there was disagreement on whether microcomputers and new technology will increase or decrease demand for additional technicians. It is expected that this will vary greatly by subject area. The age distribution of technicians is relatively even, and no shortage is expected by pending retirements of a disproportionate share of the technician population.

PRESENT AND FUTURE ROLES

For the purposes of this conference, it is more important to understand the role of the technician than to understand gross estimates of numbers. The role of the transportation technician is expanding and will continue to do so. New technology (microcomputers, automation, robotics) are enabling technicians to carry out tasks heretofore reserved for the professional. Contributing to this trend are more and better-described standard procedures, which lead to new relationships between the technician and the technical manager.

A whole new range of skills for the transportation technician is therefore needed. These include the ability to:

- Accept increased responsibility,
- Adapt to change,
- Contribute to decision making,
- Work with people, and
- Communicate verbally and in writing.

Providing these and other necessary skills to the technician will require education and training efforts beyond those applied in high school.

The shift from construction of new facilities toward rebuilding, maintenance, and management will have a significant impact on the education and training needs of the transportation technician. There is a lack of manuals and texts that address this new direction. Training institutions are not responding to this shift in emphasis. As a result, training programs for transportation technicians will need to become more sophisticated.

EDUCATIONAL REQUIREMENTS

Workshop participants spent considerable time discussing the level of education required for an individual to pursue a career as a transportation technician. The current situation in terms of employer-established education requirements for the entry-level employee and available college education programs were viewed as insufficient to meet the knowledge needs described in the report of the previous session. Participants agreed that the industry-wide goal should be to strive toward an entry education requirement of an associate degree in transportation technology.

The associate degree in transportation technology, as opposed to an undesignated associate degree, is viewed as necessary to qualify the individual for job situations that will have to be handled in the expanding role of the transportation technician. Participants agreed that the associate degree curriculum should be structured so that it emphasizes a basic education that will be applicable to technician positions associated with all transportation modes. The basics should be addressed by including in the curriculum the following topics:

- Precalculus mathematics;
- Computer applications;
- Oral, written, graphic, and visual communication;
- Supervisory skills;
- Data collection and analysis, including instrument familiarity and use of statistics;
- Introduction to transportation, including mode characteristics; technical, political, economic and legal aspects, and people interactions; and
- Physical science as related to the selected career direction.

In addition, it was agreed that the curriculum should be flexible enough to include some coverage of concepts and methods associated with specialty topics related to the selected career direction.

Workshop participants believed that the proposed associate degree can be implemented by community and other colleges with minimal additional resources because resident faculty would be qualified to do most of the needed instruction. Highly specialized faculty, equipment, and laboratory facilities as associated with engineering technology associate degree programs would not be required, but employer-provided training for the specialty area work the graduate will be hired to do will be necessary.

Of concern to participants is that upward mobility for technicians is limited in government agencies because of civil service paths that stop advancement at an early age and normally contain the individual within a narrow specialty area. This situation is viewed as promoting employee disenchantment and resistance to professional development. Participants believed that it is essential that continuing education for technicians become standard practice because technical currency will be essential in the expanding role of the transportation technician. It is the opinion of the workshop participants that current employer training efforts for technicians are, for the most part, not given high priority and, therefore, employers will have to change their attitudes and increase technician training efforts using the entire spectrum of delivery methods. Employer support of technician training on a continuous basis will, in the opinion of the participants, have to be financed by a line item in the annual budget that could be keyed to a percentage of the salary burden. It is also the opinion of the participants that it would be desirable to identify the training needs of the individual by joint action of the supervisor and the technician.

Workshop participants discussed the presence of minorities in technician positions, and it was believed that the technician career path should be an attractive career path for everyone, including minorities. They also believed that organized national efforts must carry more messages about careers in transportation to high school counselors and to students and teachers in junior and senior high schools. A concern of the participants is that there may not be enough recognition of the fact that the transportation technician must perform in a technical environment in which English is the operating language and, therefore, special training efforts may be necessary for minorities whose primary language is not English. Participants also asked if the historically black colleges are giving enough attention to associate degree programs that can provide transportation technicians.

Finally, the participants expressed some concern about the 5-year study period of the Transportation Professional Needs Study (1) and whether it can take into account all the factors that are constantly emerging.

REFERENCE

1. Transportation Professionals: Future Needs and Opportunities. Special Report 207. TRB, National Research Council, Washington, D.C., 1985.

Carrier Management and Physical Distribution Personnel

Workshop participants concluded that to the extent that problems exist related to the demand and supply of transportation professionals, such problems are caused by a set of exciting and positive changes among shippers, carriers, and the governmental and regulatory environment.

DEMAND FOR TRANSPORT PROFESSIONALS AMONG SHIPPERS AND CARRIERS

The initial issue addressed by the workshop participants was to identify those factors in the external environment that are exerting the most influence on the demand for and the types of transport professionals required today by shippers and carriers. It was noted that this represents more than 30,000 logistics professionals identified in the recent survey of shippers alone.

Three factors were clearly identified for change.

1. Deregulation of passenger and freight modes. Before 1980 most transport modes were characterized by a relatively protected marketplace in a highly regulated environment. Both shipper and carrier were insulated from change. Since 1980 a free market has been effectively created by a dramatic swing toward deregulation. There has been a dramatic increase in the pace of change, which has been especially important given the relative stability of the environment before 1980.
2. There has been a simultaneous concentration of much of the transportation industry in concert with the introduction of hundreds of new entrants. With few exceptions, the traditional carriers in the marketplace are increasing in size, especially through intra and intermodal mergers. At the same time, freedom of entry provided by deregulation has permitted the creation of new carriers and services. Well-known examples include Federal Express and People's Express. In addition, hundreds of brokers, dealmakers, and other entrepreneurs have taken advantage of opportunities that were simply prohibited by law before 1980.
3. There has been a discovery, especially among major manufacturers in this country, that logistics matter. A just-in-time or zero-defect approach to manufacturing and quality control have made both logistics and thereby transportation activities a key part of many shippers' corporate strategies.

What Type of Transport Professional Is in Demand in the Private Sector?

- An effective professional must be responsive to a complex marketing and manufacturing environment.

- A confident professional must be responsive to rapid change both internally and externally.
- A confident professional must be capable of the analysis required to comprehend and productively change complex transport systems.

WHAT SET OF SKILLS SHOULD A CONFIDENT TRANSPORT PROFESSIONAL POSSESS?

A generic set of competency skills:

- A broad-based and intradisciplinary education.
- Sound training and analytic methods.
- The ability to organize information succinctly and present it in a coherent fashion.

Emerging needs to be effective in the new deregulated environment; the transport professional must

- Possess key marketing skills that can be applied in a transportation and logistics context.
- A fundamental understanding of the cost structure of transport activities.
- A fundamental comprehension of the systems issues apparent in transport problems.
- An understanding of the role of transportation in the international and world economic context.
- An understanding of the relationship between infrastructure issues and carrier or shipper actions.
- An entrepreneurial spirit and a willingness to innovate. It is obviously needed in start-up ventures, but equally so in existing carrier and shipper operations given the pace of change in the total transport environment.

ARE CANDIDATES AVAILABLE AND ATTRACTABLE?

The changing environment for both shippers and carriers is both a positive and a negative factor with respect to finding and attracting qualified candidates. On the positive side, carrier and shipper management offers more opportunities relative to other endeavors than has been true in the past. On the negative side, few candidates have a commercial-business-entrepreneur skill set combined with a fundamental (analytic) knowledge and understanding of the workings of transportation systems. Thus, the result is better generally qualified candidates who may require significant additional education to ensure that they have the requisite transportation-specific skills that have become more important in this new environment.

SUMMARY OF DEMAND ISSUES

The conclusions of participants in this workshop might well be summarized in the words of commentator and author Ben Wattenberg: "The good news is the bad news is wrong!" There are tremendous opportunities in the transportation field, especially in the private sector. The primary need is to communicate this fact to educators and students. Taking advantage of these opportunities will require evolutionary, rather than revolutionary change.

Education and Training Needs

Workshop participants' discussions focused on identifying those changes in existing programs that would be most likely to increase the supply of good transportation professionals for shippers and carriers.

The Image Problem

Any discussion of changes to educational programs must first deal with some of the shortcomings of what is already there. There is no denying that the demand for the existing product is decreasing. Enrollments are down in both engineering and business programs. This is partly due to the natural business cycle emphasized in the paper titled "Efficient Utilization of Transportation Research and Educational Resources" elsewhere in this report; that is, demand leads supply. In an attempt to reverse this trend, however, quality standards must not be abandoned. The business community wants high-quality graduates, not large numbers of less-qualified graduates.

To reverse enrollment trends, the word must be spread that there are opportunities in transportation. Better recruiting materials might be the answer; both educational programs and employers should participate. The professional societies can also take the lead. The brochure that describes careers in physical distribution, distributed by the National Council of Physical Distribution Management, is an excellent model for the requirements of the transportation industry. Materials such as success stories and role models are also needed to interest students in transportation programs. This problem encompasses all areas of transportation, so it might best be addressed by an intersociety committee.

Workshop participants suggested, only partly in jest, that a name change might be required. The terms "transportation" and "traffic" conjure up visions of clerks in green eyeshades working in dusty basements. In reality, the modern physical distribution professional is more likely to spend a significant amount of time working with his desktop computer. Terms such as logistics management, physical distribution management, or logistics engineering might better describe the type of work that is done by transportation professionals who work for shippers or carriers. In selling transportation programs there is a need to emphasize what transportation professionals do, how much responsibility they have, the leverage that they exert on total production costs, and so forth.

University Programs

Closer linkages need to be developed between the universities and the industry that they serve. The following mechanisms are suggested:

- Industry participation in university research, including direct sponsorship of projects and participation in cooperative research ventures;
- Internships and summer jobs for transportation students;

- Use of university faculty as visiting scientists in industry;
- Faculty consulting with transportation companies and shippers;
- Use of adjunct faculty from industry in the universities;
- On-campus seminars presented by industry professionals;
- Plant visits by students and faculty;
- Advisory committees from the transportation industry; and
- A formal affiliates program whereby companies sign up for a special relationship with the university transportation program.

The needs of the transportation industry would be served better if there were a greater degree of cooperation between the engineering programs and the business programs. This might involve research by interdisciplinary teams, students taking courses in both colleges, cross-listing of courses, joint degree programs, and so forth.

The universities must make their programs flexible and adaptable to deal with the changing nature of transportation. The programs should emphasize providing the students a general core of analytic skills, whereas the specific applications of those skills can be tilted to reflect current issues. For example, deregulation of the marketplace implies that transportation professionals need the following basic skills:

- Economic analysis,
- Cost determination,
- Administrative law,
- Political analysis,
- Negotiation, and
- Analysis of complex problems.

While providing these skills, the universities should maintain emphasis on analytic methods and computer applications.

One approach the universities could adopt is to increase the infiltration of transportation subjects into other courses, especially in business schools. That is, courses in finance could include case studies of transportation company finance, marketing courses could include marketing of services such as transportation services, and so forth. There are cases available for this purpose, and more cases need to be provided for general business school use.

Finally, universities could help to reverse enrollment trends by increasing the excitement of the introductory transportation courses in both engineering and business. It is typically through a good experience in such an introductory course that a student is motivated to study further or major in transportation. If these courses are made intellectually stimulating and exciting, a larger proportion of the better students will elect transportation careers.

Continuing Education

Three distinct types of continuing education experiences are needed in freight transportation:

- Specialized training to update technical skills; current needs are for training in costing, market planning and analysis, microcomputers, and infrastructure rehabilitation and management.

- Transportation management for new executives with transportation responsibilities who come from nontransportation backgrounds.
- General management courses, such as the executive development programs currently offered by a number of leading universities, for "rising stars" who are being groomed to assume high-level executive positions.

All three types of continuing education are available and are being used by the transportation industry. More high-quality offerings of this type can probably be supported.

There are impediments for universities and other providers to developing continuing education courses for transportation professionals. First, there is a front-end risk of investing in the development of a course that may or may not succeed and that will require heavy marketing for an extended period of time. Second, there are large economies of scale in the continuing education business. It makes sense for a few institutions to offer a large number of courses, thereby supporting a core management staff. Third, it is difficult to provide good continuing education; it requires dedicated professionals with a sensitivity to the needs of the adult professional course participant and with the commitment required to maintain the currency of the offering. Finally, in the case of universities, the usual reward structure does not recognize the significance and importance of continuing education programs, therefore faculty are reluctant to spend much time on them.

In-House Training Programs

The transportation industry is currently using many types of in-house training programs, including those provided by universities, company-developed programs, courses offered by suppliers and vendors, private training institutes, programs at vocational-technical schools, and others. These activities already exist and are highly focused and effective. There is no apparent need for any significant changes.

Technical Training

A considerable reorientation in the training of transportation technicians for the freight transportation industry is currently underway. Previously, much of this training focused on rating and routing of shipments and construction and interpretation of tariffs. These skills are no longer necessary in the current largely deregulated environment. Instead, there are now demands for technical skills in costing methods and in world trade, to mention two emerging areas of major importance. Market research and microcomputer applications are other areas where demand for technicians, or for retraining of technicians, will likely be high.

Research as an Educational Resource

Workshop participants were of the opinion that the fact that a graduate had worked on research projects was probably more important than exactly what the research entailed. Participation in research breeds a graduate who tends to have take-charge type leadership skills. The transportation industry needs to recognize this and actively support research in university transportation programs. Also, the industry does do a fair amount of research, or problem solving that borders on research, and could, therefore, benefit by having available graduates with research skills. There are numerous examples of companies that have benefited by employing such individuals.

Women and Minorities

Workshop participants echoed the discussion by Dorsett and Benjamin in "Transportation Careers for Minorities" elsewhere in this report. There definitely are opportunities for women and minorities in transportation, especially in the freight transportation business. Transportation is usually a secondary career choice for someone who elects to study a broader field such as business or engineering; therefore, transportation programs are at the end of the recruiting pipeline and can exert little influence on their own for encouraging women and minorities to major in transportation. Historically, largely for cultural reasons, women and minority students have disproportionately elected nonanalytical programs, which would prohibit them from entering a transportation career in later years. However, the quantitative skills required in transportation are basic enough that quick catch-up is definitely possible. Thus, the transportation industry should participate in recruiting programs to ensure that prospective candidates elect appropriate studies early in their educational careers. This can be done by emphasizing that there are significant opportunities for women and minorities in transportation.

Computers in the Classroom

Workshop participants emphasized that the transportation business needs people who are adept at complex problem solving. If computer technology can help, it should be used. There is a danger here of emphasizing the technology and ignoring the underlying application of the technology.

Computer training is definitely a necessary part of the education of the modern transportation professional. The educational programs need to make available computer training that goes beyond the mere computer literacy that many institutions are now emphasizing. The graduate must be proficient, not merely literate.

SUMMARY

In summary, "The good news is the bad news is wrong!" can be repeated. This conference was largely conceived amid the gloom and doom of declining enrollments in traditional transportation programs. However, the sense of optimism that pervaded the conference was clearly evident in this workshop. There are tremendous opportunities in the transportation field. The transportation industry must get the word out to prospective students, and be sure that transportation programs adapt to the evolving needs of the transportation industry.

Part III Resource Papers

Demand for Transportation Education: What Should the Product Be?

SUMMARY OF PAPERS

Louis J. Pignataro

The topic for discussion in this session is "Demand for Transportation Education: What Should the Product Be?" and I will begin by summarizing the papers prepared by the authors. Although some of the authors discuss some common considerations, such as the impact of the microcomputer on the transportation profession, it is more useful to summarize each paper separately. However, if there is reinforcement of the same point by more than one author, I will attempt to make note of this concurrence of ideas. At the conclusion of my summary, I will pose some questions for consideration by the panel and the audience.

The authors and their topics are as follows:

- Transportation Education: Educating Tomorrow's Transportation Planners, Michael D. Meyer.
- Educating Tomorrow's Transportation Engineers, Thomas D. Larson and Harvey Haack.
- Transportation Education: Training Requirements for Transportation Technologists, Donald L. Woods, A. Nelson Evans, and Charley V. Wootan.
- Education Requirements for Transportation Consultants, Wilbur S. Smith.
- What are Shippers and Carriers Looking For?, Gayton E. Germane.
- Training Requirements for Transportation Operations Personnel, James E. Reading, Barbara A. England, and James W. Strecker.

TRANSPORTATION EDUCATION: EDUCATING TOMORROW'S TRANSPORTATION PLANNERS

Meyer reviewed several studies conducted during the last 5 years that were concerned with an examination of the purpose and scope of transportation planning. From these studies he established a number of propositions and subsequently used them to define the desired characteristics and attributes of transportation planners. These propositions included the following:

1. Among many planners there is a growing distinction between strategic planning and systems planning. There is a shifting of emphasis from systems planning (i.e., how best to develop, operate, and manage a transportation system) and a move toward strategic planning (i.e., how best to meet the challenges of the future and prepare for a changing environment).
2. Regional transportation planning agencies are becoming more concerned about satisfying local community needs than about meeting federal planning re-

quirements. This shift has been fostered by cutbacks in federal funding and, therefore, increased funding from state and local sources, which has resulted in greater accountability to the latter. The consequence of this change is a greater concentration on short-range problems, providing more visible results to local constituencies.

3. Rapid computer analysis capability is making planning more relevant to decision makers. Microcomputers have provided planners the capability of analyzing problems and producing results much more quickly.
4. Increasing focus on rehabilitation and system maintenance will create increasing pressure for implementation-sensitive planning. This shift has been fostered by a widespread recognition of the critical need to rehabilitate and rebuild the public works infrastructure, particularly in the older cities, which results in a greater concentration on effective implementation than system development.
5. There are many planning processes in an urban area that require alternative styles of planning. All of the previous four propositions reinforce this fifth one; that is, effective transportation planning must be more flexible in developing alternative planning approaches and more responsive to the needs of decision makers by providing additional relevant information.

Based on these propositions, Meyer concluded that an effective transportation planner is one who possesses the following attributes:

1. Ability to understand the decision-making process. It is necessary for the transportation planner to not only have a thorough knowledge of the decision-making process but to also understand the environment in which the decision maker must operate.
2. Ability to define the problem and identify the problem-solving approach in an appropriate manner. It is necessary for the planner to define the problem in a comprehensive way to ensure the most appropriate response or solution, considering available resources and the needs of the decision maker.
3. Ability to understand implementation concerns. It is necessary for the planner to have a thorough understanding of the myriad potential obstacles that may be encountered in project implementation.
4. Ability to utilize the most appropriate analysis methodology and techniques. This capability is directly related to the ability to define the problem.
5. Ability to incorporate basic community (or organizational) values into planning efforts. It is necessary for the planner to describe the consequences of alternative planning approaches as comprehensively as possible to permit the decision maker the opportunity to assign judgmental values to the potential consequences of his or her decisions.
6. Ability to communicate information. Meyer made no attempt to correlate these attributes with programs of study or specific courses because of the difficulty of evaluating what can be taught and what can be developed through experience.

EDUCATING TOMORROW'S TRANSPORTATION ENGINEERS

Larson and Haack believe that, because of the broadness of the field, it is not possible to define a discrete body of knowledge that should be used as the basis for educating transportation engineers. To arrive at a better understanding of the implications for engineering and engineering education, Larson and Haack, like Meyer, examined a number of trends in transportation. The impacts of these trends are primarily related to a public transportation agency. These trends included the following:

1. Systems development to systems management. There is a shifting of emphasis from transportation system development toward transportation system management. This shift has resulted in greater fiscal responsibility and a more business-oriented approach to transportation programs.
2. Subject technology to public acceptance. There is a tendency not to use technology until it is thoroughly understood by the various constituencies that are affected by it. This has resulted in a greater sensitivity to and interaction with local officials and the public.
3. Pocket calculators to personal computers. The shift to greater and more rapid computer technology facilitates the ability of a public agency to establish adequate control systems for overall monitoring and management. Management control is reinforced and enhanced by computer-assisted design and drafting and office automation.
4. Federal government to local government and private enterprise. The shift from federal government intervention in transportation to state government and from state to local government has resulted in greater reliance on local management and greater accountability. A ramification of this shift is an increased use of private contractors as a means of achieving more cost-effective operations.
5. Research to innovation. The shift from unsuccessful attempts to apply high technology in the design, control, and operation of transportation systems to innovative approaches to solving more traditional transportation problems, such as infrastructure materials and technology and bridge and pavement rehabilitation, has resulted in a resurgence of interest in transportation research. However, it would be a serious omission not to mention the successful application of high technology to transportation achieved by other countries of the world.

It is interesting to note that there is practically 100 percent overlap between the shifts regarding transportation planning and those regarding transportation engineering as identified by Meyer and Larson and Haack.

After identifying the preceding trends, the authors defined the "ideal" engineer for transportation as "well grounded in basics and capable of solving unique problems in creative, imaginative, high-tech ways." This individual should also have the ability to work independently or as part of a team, and should have the ability to interact and communicate successfully with others. The individual should also possess entrepreneurial capabilities and an understanding of domestic and international political structures. In addition, the individual should exhibit high moral standards, leadership qualities, and the ability to fit transportation systems into the social, economic, and physical environments in such a manner that the quality of life would be improved for all.

Based on the observed trends in transportation and the definition of a model engineer, the authors drew conclusions about impacts for education and industry. With respect to education, they indicated that an impact must be made on all levels of education in order to produce the model engineer; greater emphasis must be placed on developing individual capabilities commensurate with the individual's ability.

With respect to industry, the authors discussed the implications with regard to the experienced engineer, the engineer-in-training, the engineering profession, and the involvement of industry in education. Various techniques were identified to avert the danger of stagnation of experienced engineers, including job rotation, retraining, in-house training, and continuing education. The engineer-in-training should be challenged as early as possible to perform to the full extent of his or her capability. For the engineering profession, it is necessary to develop and promote the image of engineering and the attractiveness of engineering as a career path. Industry's involvement in education can take several forms, including encouraging employees to run for membership on local school boards and to be guest speakers, adopting a secondary school type of program, providing summer jobs and internships, making funds and equipment available to institutions of higher learning, encouraging employees to assume adjunct faculty positions, and encouraging full-time faculty to accept a short-term appointment to industry as a visiting scientist.

TRANSPORTATION EDUCATION: TRAINING REQUIREMENTS FOR TRANSPORTATION TECHNOLOGISTS

Woods et al. indicated that there is a growing need for technicians in transportation. They considered the engineering team to be made up of engineering technicians (presumably graduates of a 2-year certificate program), engineering technologists (graduates of a 4-year bachelor of technology program), and engineers (graduates of a 4-year bachelor of science or engineering program). As used in their paper, the term technologists included both technicians and technologists.

Because of the widespread availability of microcomputers, many functions previously carried out by engineers are now relegated to technologists who can be readily trained to execute routine technical data processing. The engineer's main function, in this regard, is the interpretation of results rather than the performance of computational work. He or she can be provided with several alternative solutions to a given problem from which the most suitable solution can be recommended on the basis of whatever criteria are established for project evaluation. The role of the engineer becomes more creative and management-oriented. This same point is strongly made by Larson and Haack.

The authors anticipated that there will be a much greater change experienced in transportation engineering as compared with the more traditional branches of engineering. They attributed this to two factors: (a) the shift from capital programs to transportation system management programs and (b) the shift from mainframe computers to microcomputers. The ramifications of these shifts are that the engineer's functions will become more associated with project management, technical decision making, and research.

Regarding the implication for academic institutions, the authors perceived a change in orientation of some institutions to satisfy the increased demand for technologists. They believed that the more practice-oriented technical training will largely become the domain of the smaller technical institutions, and that, presumably, the graduate transportation pedagogical and research programs will be the domain of the universities. The role of the universities will continue to be to educate and train professionals for industry and faculty for technical institutions as well as for universities, and to provide for technology transfer in training and implementation.

The authors indicated that there are two basic needs for training transportation technologists: (a) technical training to prepare technologists for entry-level positions and (b) retraining those currently employed as technologists. These training needs will be provided by four sources including (a) in-house training, (b) equipment manufacturers, (c) technical societies, and (d) technical schools.

The authors identified various skills required to properly train civil engineering technologists, and they supplemented this listing of basic skills with specific skills associated with specialization areas of transportation stratified into (a) highway and street design; (b) surveying, mapping, and field location; (c) traffic control; (d) construction and maintenance; and (e) public transportation.

EDUCATION REQUIREMENTS FOR TRANSPORTATION CONSULTANTS

Smith believed that the training required for employees of transportation engineering consultants does not basically differ from that required of all types of engineering consultants. However, he indicated that there is almost no restriction on the use of a wide range of disciplines in transportation engineering consulting because of the broad array of services offered. Most projects require articulated teams of individuals from different disciplines. Larger firms can support highly specialized professionals, but both small and large firms require more broadly educated engineering professionals.

Smith believed that transportation engineering may more likely be subjected to rapid changes in technology as compared with some of the traditional engineering disciplines, recognizing, for example, that we are on the verge of space transportation that will draw on the innovative talents of those engaged in the transportation field.

He also pointed out somewhat unique characteristics of transportation consulting, including the need to be particularly sensitive to client needs, working excessive hours, carrying on additional study and research beyond working hours, and extensive travel with a substantial portion of it taking place beyond working hours.

Smith indicated that consulting engineering firms require individuals who are innovative and who have high personal and professional goals, an entrepreneurial drive, adequate verbal and oral communication skills, an acquaintanceship with business administrative activities (particularly accounting principles), and marketing skills. He believed that civil engineering provides the best undergraduate background for transportation consultants, supplemented by elective courses in transportation, economics, business administration, marketing, and international studies. Individuals who receive a substantial amount of training in nontechnical courses are generally preferred by transportation engineering consultants. Where a high degree of specialization is required it must be acquired in graduate school.

Smith's description of the attributes that should be possessed by those working in transportation consulting offices compares closely with the ideal engineer described by Larson and Haack.

Smith used the United Kingdom to illustrate the long-established practice in many European countries of articulating the training of professional engineers and engineering technicians. He believes this practice could result in maximizing productivity. He recognized the importance of in-house training, continuing education, and the need to encourage employees to participate in professional activities.

The paper concluded with the thought that the transportation professional today is involved in a complicated process of planning, design, and management of projects, and, therefore, it is not as important to become highly proficient in one component of transportation as it is to have a better understanding of how all the components fit together.

WHAT ARE SHIPPERS AND CARRIERS LOOKING FOR?

Germane discussed the attributes that individuals should possess to assume entry-level management positions and to assume major responsibilities in his or her profession in later years. In establishing these criteria, he drew not only on his own considerable experience but also on the opinions expressed by senior-level executives from various modes of transportation.

He presented several characteristics that shippers and carriers would look for in judging the qualifications of an individual. The person should be (a) intelligent, (b) industrious, (c) personable, and (d) should possess basic knowledge and skills. The evaluation of attributes is largely done by indirect measures such as grades, awards, recommendations, and more direct measures obtained by interviewers. This process is quite satisfactory in selecting an individual for an entry-level position, but not necessarily in judging the potential of an individual to assume significant responsibility in the future.

With respect to the prospects for significant advancement, Germane identified three considerations, including (a) determination, (b) imagination, and (c) judgment. These attributes are difficult to evaluate by interviews, performance in school, or records, and they are generally determined by providing opportunities for progressively greater responsibilities and observing performance. He provided many excellent examples (or mini-case studies) to illustrate the attainment of the qualities of determination, imagination, and judgment.

In conclusion, Germane made several suggestions to enhance the development of these qualities. With respect to determination, he recommended (a) use of guest speakers to discuss the role of leadership in reaching objectives, (b) review of biographies and history to find examples in which individual determination was a significant factor in obtaining goals, and (c) use of case studies to illustrate the role of determination in decision making.

With regard to imagination, he suggested (a) use of case studies to illustrate how development changes significantly with time to stimulate imagination, (b) discussion of material associated with the commercial development of outer space, (c) use of problem cases based on current innovations, and (d) use of problem cases with no standard solution.

With respect to developing judgment, he advocated (a) practice in evaluation of choices through problem cases or research projects, (b) experience in making the various decisions required in the development of a plan, and (c) use of guest speakers to discuss the analysis and evaluation preceding the making of a particularly difficult decision.

In conclusion, Germane noted that "for maximum benefit, we need to shape our questions and comments carefully since they structure the responses we will obtain."

TRAINING REQUIREMENTS FOR TRANSPORTATION OPERATIONS PERSONNEL

Reading et al. discussed the skills required for transit operations personnel and the training provided after individuals are hired. Using the Operations Division of the Central Ohio Transit Authority as a case study, the authors examined the different training and other qualifications a transit authority might require of their employees as well as training opportunities they should be offered for the purposes of self-motivation and enhancing the possibility of advancement.

For higher level positions such as assistant general manager, operations executive assistant, and superintendents of different departments, the authors believe that in addition to competency in the area of specialization, a degree in business administration is desired.

Operations are generally divided into the major functional areas of transportation, maintenance, and building and grounds; each area is headed by a superintendent. The majority of motor coach operators, clerical staff, maintenance staff for equipment and buildings, and other positions, are unionized. After selection for most of these positions, employees are given on-the-job training, possibly supplemented by special training offered by equipment manufacturers.

Employees are provided various incentives to enhance job performance and opportunity for advancement through training and education activities, including (a) tuition reimbursement programs for courses and for continuing education, (b) reimbursement for expenses incurred in attending and participation in professional meetings, and (c) contracting for training programs.

The authors concluded with the observation that a dynamic process exists, and that the success of the process depends on the realistic assessment of skills needed for various positions and the establishment of a comprehensive program to develop further technical skills, leadership qualities, and the ability to deal effectively with others and with problems.

QUESTIONS FOR CONSIDERATION

1. The corporate sector adopted strategic planning about 10 years ago and, apparently, has abandoned the approach. Is government behind the times in its shift from system planning to strategic planning in light of the corporate sector's experience?
2. Will the shift from federal government intervention in transportation to state government to local government and the consequent focus on short-range problems have a stifling effect on innovation and research initiatives?
3. Is U.S. technology leadership challenged? If so, what are the implications of this challenge?
4. Is there not a need to develop research and implementation approaches to using technology more effectively in transportation?
5. What is the impact of the inability of governmental agencies to attract and retain transportation engineers in competition from the private sector?
6. Billions of dollars are being spent annually by all levels of government to rehabilitate and rebuild the infrastructure of major urban areas as well as public works throughout the nation. What should be the impact of this substantial commitment of resources on education, training, and retraining?
7. There has been little discussion by the authors of the impact of deregulation on transportation planning and engineering. What has been the impact of

operating in an increasingly deregulated environment? What are the implications for transportation education and training?

8. Although the student must be taught to cope with the rapid rate of obsolescence of his professional background, there is an indisputable need for continuing education programs. Is there a need to intensify continuing education efforts?

9. What is the impact of disproportionate enrollment of non-nationals in engineering, particularly at the graduate level?

10. The ability of universities to produce the best is jeopardized when second- and third-rate equipment, obsolete instrumentation, and inadequate library collections are used. University instrumentation inventories are nearly twice as old as those of leading commercial laboratories. The ivory towers are now in industry. What will the impact be of the deteriorating university infrastructure and the obsolescence or unavailability of instructional equipment and facilities, such as hardware required to provide students with experiences in computer-aided design, mapping, and drafting and office automation at many institutions?

11. Engineering educators are concerned about the decrease in the proportion of programs in engineering receiving certification from the Accreditation Board for Engineering and Technology. Is the quality of engineering education deteriorating?

Transportation Education: Educating Tomorrow's Transportation Planners

Michael D. Meyer

Many recent studies on the deterioration of the public infrastructure in the United States have concluded that an effective planning process is an essential element of a government's response to meeting capital investment needs. In at least one instance, a study further concluded that "if planning is to assume a central role in influencing public capital investments, it is important to ensure that the people doing the job have experience of how agencies operate and understand the day-to-day problems faced by those managing public programs and facilities" (1). The purpose of this paper is to examine, within the context of a changing political and fiscal environment of transportation decisions, these and other planning skills desired by transportation organizations. In the first section of this paper recent studies of the changing nature of transportation planning are reviewed. This section concludes with several propositions on what, in general, appear to be the likely characteristics of transportation planning in the future. In the second section these propositions are related to the desired skills of transportation planners.

REEXAMINATION OF TRANSPORTATION AND TRANSPORTATION PLANNING

During the past 5 years, many transportation professionals have begun to reexamine the purpose and characteristics of transportation planning. In part, this reexamination has occurred because of Altshuler's argument that "urban planning is a public activity whose theories and preoccupations at any moment in time closely reflect the government programs and political moods which are currently dominant or which have been in the recent past" (2). Given the changing federal role in transportation programs, coupled with dramatic improvements in analysis capability due to the evolution in computer technology, it is not surprising to observe serious efforts in defining the likely characteristics of future transportation planning. Several of these efforts will be described in the following paragraphs.

TRB CONFERENCE ON URBAN TRANSPORTATION PLANNING IN THE 1980s

Periodically, transportation professionals gather under the auspices of the Transportation Research Board to discuss the future of urban transportation planning. Such a conference was held in 1981 and, given a new administration, played an important role in reshaping federal transportation planning regulations (3).

Some of the important conference observations on the characteristics of future urban transportation planning included the following:

1. Non-federal decision makers will likely play an increasingly important role in determining planning process and product requirements. Thus, there will be a greater concern among regional transportation planners for meeting the short-range, perceived needs of local communities.
2. Planners will become increasingly concerned with issues such as system rehabilitation and cutback management in older cities and managing continuing growth in newer cities.
3. The regional transportation planning process will become more concerned with corridor, subarea, and project planning.
4. Economic, fiscal, and pricing issues will become more central in urban transportation planning. Related to this was the need for more sophisticated analysis tools and a better theoretical understanding of general system relationships.

In one workshop, conference attendees also concluded that a wide variety of skills--communications, negotiations, design, brokerage, conflict resolution, consensus building, education, and coordination--will be required of planners to meet the demands they will likely face. Such a broad skill mix was considered essential to the success of planning efforts in metropolitan areas.

Study on the Role, Functions, and Effectiveness of Metropolitan Planning Organizations

In 1974 the federal government required each major urban area to establish a metropolitan planning organization (MPO) that would coordinate the regional transportation planning process for the urban area. Although MPOs are structured differently from one city to another, they often possess important transportation planning capability for urban areas, and thus their overall role and function are an important concern in this paper.

A 1983 study on the roles and effectiveness of MPOs revealed several interesting observations on the current status of MPOs (4). First, the more the MPO was oriented toward local and regional leadership and governmental units, the more effective it was in serving the region with appropriate regional planning services. Second, an important function for MPOs in the 1980s was considered by Tomazinis et al. (4) to be the exploration of "strategic" future directions for the region; for example, choosing targets for regional economic development, assessing future risks facing a region, and working together with the public and private sectors. Third, MPOs will likely become more involved with the implementation planning of regional projects that require the coordination of numerous governmental units. Finally, and somewhat redundant to the first observation, MPOs will likely increase their orientation toward the localities they serve to meet local ad hoc regional planning needs and developmental objectives.

Rebuilding America

An increasing concern with the deteriorating infrastructure in the United States has spawned numerous studies designed to identify the most cost-effective means of meeting infrastructure needs. In one of the latest studies, entitled *Rebuilding America: Planning and Managing Public Works in the 1980s* (1), a great deal of attention is focused on the importance of strategic planning, the purpose of which is to assess an organization's strengths and weaknesses as they relate to anticipated threats or opportunities in an organization's environment. Strategic planning, as discussed in this study, has four important aspects that warrant special attention.

1. Planning is a continuous process of setting broad objectives, devising appropriate policies, and communicating decisions.
2. The management of the flow of information is a central element of the planning process, as is the communication of information to different constituencies.
3. Planning is an alchemist's amalgam of science and art, and thus a planner must avoid an overreliance on sophisticated planning and economic models.
4. Establishing a strategic planning process is difficult because it requires busy managers to set aside time to think and to write.

The important aspect of this study is that it recognized the need for a strategic planning process to handle the issues related to rebuilding America's infrastructure and did not emphasize at all the more traditional systems planning approach.

AASHTO Session on the Evolution of Transportation Planning

In March 1984, the Standing Committee on Planning of the American Association of State Highway and Transportation Officials (AASHTO) conducted a session on the evolution of transportation planning (5). Although much of the discussion at this session focused on the history of "tactical planning," that is, the planning that produced today's transportation system, several participants argued that the future of planning was most likely to be in the area of strategic planning. Strategic planning was defined at the session as "planning that takes what we have and seeks to build something an order of magnitude more productive out of it" (6). Indeed, in at least one state, Pennsylvania, the strategic planning concept has become the central theme for the agency's structure and management.

The preceding four studies represent only a few of the numerous efforts that have been made to reexamine the planning process and to define its likely future. These studies, along with my own experience and research in transportation planning, lead to the following propositions that will guide subsequent discussion on the desired characteristics of transportation planners.

Proposition 1: Is There a Growing Distinction Among Many Planners Between Strategic Planning and Systems Planning?

Transportation planners have traditionally focused on systems planning, that is, how best to develop, operate, and manage a transportation system. In numerous transportation organizations, professionals are now becoming more concerned with the ability of the organization to meet the challenges of the future and to prepare for a changing environment. This is not to say that strategic planning and systems planning cannot exist together in an organization. Rather, in these organizations, the task of supporting the strategic planning process has been given to the planning departments, thus requiring a new perspective on the role of planning within the agency.

Proposition 2: Regional Transportation Planning Agencies (MPOs) Are Becoming More Concerned About Satisfying Local Community Needs Than Meeting Federal Planning Requirements

With cutbacks in federal planning funds and regulations, regional transportation planning agencies are becoming increasingly concerned about being "relevant" to local communities. This has shifted resources (financial and personnel) away from long-range issues to shorter term, more pragmatic problem-solving approaches. In Massachusetts, for example, many regional planning agencies are conducting traffic engineering studies in constituent communities to show visible products of the planning effort, and the state is urging the agencies to become more involved in local implementation issues.

Proposition 3: Rapid Computer Analysis Capability Is Making Planning More Relevant to Decision Makers

For many years, transportation planners either relied on cumbersome computer models that took a long time to produce results or on overly simplistic models that were not believed. With the rapid evolution in microcomputer technology, planners now have the capability to analyze problems and produce results quickly. It appears likely then that microcomputer-based planning will become a predominant form of planning in the years ahead.

Proposition 4: An Increasing Focus on Rehabilitation and System Maintenance Will Create Increasing Pressure for Implementation-Sensitive Planning

In its heyday, transportation planning played an important role in developing today's transportation systems. Today, many of these systems are in need of repair and rehabilitation, and the important issues are more related to effective implementation than to system development. A good example of this type of planning can be found in the rather extensive planning efforts that have preceded the reconstruction of major urban expressways in Boston, Chicago, Philadelphia, and Pittsburgh.

Proposition 5: There Are Many Planning Processes in an Urban Area That Require Alternative Styles of Planning

Traditionally, transportation planning has been viewed as a systems-oriented, analytically based framework for solving transportation problems. Today, an increasing number of transportation professionals are viewing planning as a decision-oriented process that provides necessary information to those who make decisions. Such decision-oriented planning must exhibit flexibility in problem solving and a sensitivity in understanding constituent concerns.

TRANSPORTATION PLANNERS TO MEET THE CHALLENGES OF THE COMING DECADE

Perhaps the most important proposition discussed earlier with regard to its impact on the desired characteristics of planners is Proposition 5; that is, effective transportation planning requires alternative styles of planning and, thus, transportation planners who exhibit flexibility in planning approaches. The literature is full of articles on what planners should be, with each article most often based on an implicit view of the appropriate form of the planning process (7,8). And, more recently, there has been sufficient interest in the issues relating to planning that serious consideration is being given to providing greater planning exposure to civil engineering students (9,10).

Although interesting from the perspective of debate, these "ideal" planners cannot possibly represent a single image of effective planners because different organizations view the desired planner in different ways. If the premise is accepted that a major purpose of transportation planning is to provide information to those who make decisions, then the different decision-making frameworks and styles that exist in a variety of organizations mean that an effective planner in one organizational setting might produce disastrous results in another.

Even with this basic premise that there is no set of characteristics for the ideal planner, several attributes of an effective planner can be identified. No attempt will be made here to relate these attributes to required courses or training opportunities because some might be difficult to teach or might be better acquired through experience.

An effective transportation planner is one who

1. Understands the decision-making process. There are several important aspects to this characteristic. Not only should a planner understand the broader decision making and policy-making structure within which decisions are made, but the planner must be aware of how the organizational environment and culture can influence these decisions. This sensitivity to organizational behavior is probably one of the most critical deficiencies in transportation planners. Another important aspect of this characteristic is for the planner to understand how planning information is used in the public decision-making process.
2. Defines the problem and identifies a problem-solving approach in an appropriate manner. Defining the problem in terms of its important characteristics and its relationship to other policy-related variables is more an art than a science. And yet, planners who can define problems in the most comprehensive and intelligent way produce more useful information for the decision-making process. After the problem has been defined, an effective planner can determine the appropriate scale and scope of analysis, including the level of sophistication needed in the analysis methodology, once again tied closely to the requirements of the decision-making process in terms of the type and timeliness of information desired.
3. Understands implementation concerns. After a decision is made to proceed with a program or project, substantial obstacles can hinder effective implementation. These obstacles can range from organizational delays to political and

community opposition. It is important when evaluating decision-making options, therefore, that implementation feasibility be an important evaluation criterion. Of equal concern is to incorporate into this evaluation an assessment of alternative implementation strategies, if it appears that serious obstacles are likely to arise in program or project adoption.

4. Uses the most appropriate analysis methodology and techniques. Similar to the second point listed earlier, the use of the most appropriate methodology and technique requires an understanding of the underlying assumptions, basic theories, and capabilities of the methods to be used. With particular regard to planning sensitivity to the often short time frame associated with decision making, the intelligent choice of analysis techniques can determine whether the results of the planning effort will be used in reaching a decision. Given the rapidly changing environment of computer technology, it does not appear unthinkable that a basic prerequisite for becoming a planner in a transportation organization in the near future will be demonstrated familiarity with the use of microcomputers.

5. Incorporates basic community (or organizational) values into planning efforts. One of the serious problems with defining planning as producing information for decision makers is that decision makers can sometimes focus on narrow and myopic concerns (especially as an election draws near). In addition, decision makers are often unable to articulate exactly what type of information they need to reach a decision. In both instances, it is essential that the planner not only provide the information desired (in the latter case, the best guess of what is desired), but also the information needed for the decision makers to understand clearly the consequences of their decision and the relationship to community (or organizational) welfare. In some sense, this attribute suggests that an effective planner acts as a social conscience for the clients he or she serves.

6. Communicates information. The basic product of planning is information. If such information cannot be communicated in an understandable form, then the planning effort has been unsuccessful.

CONCLUSIONS

With the changing political and technological environment of transportation planning, it appears likely that the types of planners desired by transportation organizations will change as well. Although it is unrealistic to describe the characteristics of an ideal planner (given different organizational expectations), there are several characteristics that merit special attention. An effective planner is an individual who understands decision making, can define the problem and problem-solving approach in an appropriate manner, understands the barriers and consequent strategies in implementation, is familiar with analysis methodology and techniques, incorporates basic values into planning efforts, and effectively communicates information.

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Educating Tomorrow's Transportation Engineers

Thomas D. Larson and Harvey Haack

Before discussing educational needs, it is appropriate to ask several obvious questions about transportation engineers. Can their work be characterized with such specificity and is there sufficient stability over time to permit defining a body of knowledge known as transportation engineering? Consider, for example, the aviation mode. The air transportation vehicle requires aeronautical engineers reinforced by others with expertise in power systems, electrical systems, computer systems, structural systems, and more. Electrical engineers, together with computer and communication specialists, build and maintain air navigation systems. To complete the picture, civil engineers and architects design the runways, terminals, and other appurtenances at the ground-air interface. And as for time stability, how many technical disciplines related to transportation have become obsolete in one professional lifetime?

So to refer to transportation engineering as a single discipline requiring a discrete body of knowledge is an unhelpful oversimplification. It is our intent, therefore, to discuss engineering for transportation in holistic terms. In particular, we will discuss some issues and trends in transportation and their implications for engineers and for engineering education remembering always that transportation touches everything we make, buy, or do. We will supplement this discussion with examples of what we have done at the Pennsylvania Department of Transportation (PennDOT) to enhance engineering education and training.

TRENDS IN TRANSPORTATION

John Naisbitt, in his best selling book *Megatrends: Ten New Directions Transforming Our Lives* (1), describes 10 super trends that emerge from the confusion of today's highly uncertain, rapidly changing world. Naisbitt writes about an information society, "high tech/high touch," networking, and multiple options, all of which have enormous implications for transportation and transportation engineering. Similarly, we can identify specific "megatrends" that will affect engineering education for transportation.

Systems Development to Systems Management

The first trend is the shift from transportation system development to transportation system management. This concept first emerged from the Urban Mass Transportation Administration in the early 1970s and created much confusion. It is uncertain even today whether the concept is well understood. From our own perspective, however, such a shift is conceptually sound and practically necessary for the survival of PennDOT.

The shift from systems development to systems management means many things. It means paying first attention to maintenance and performing maintenance work using a business-like approach. It means limited capital programs that are no longer "wish lists," but rather are grounded in fiscal reality. In an effort to become more efficient we have begun to pay more attention to "make-buy" issues and have contracted out a great deal of work to private firms.

Although PennDOT has existed for 80 years, we have spent a considerable amount of time trying to determine just what business we were in and decided that really we are in three businesses. We own and operate a significant segment of Pennsylvania's transportation system, we perform 26 million computer-based transactions each year in issuing driver's licenses and motor vehicle registrations, and we provide close to $.5 billion each year in technical and financial assistance grants for local and area transportation.

Needless to say, these businesses and the overlying fiscal, computer, and personnel systems require a rich mix of professional skills. With the well-established centers for fiscal and project control the department now enjoys, we are encouraging our 67 county maintenance managers to act as if they were in business themselves. Of course, they receive considerable direction from the central office and the district offices to which they report, but this year for the first time we have asked these county units to develop individual 4-year business plans for achieving previously developed major departmental objectives. The notion of being in the business of systems management within a larger public works agency is a new trend in transportation--at least in Pennsylvania.

Forced Technology to "High Tech/High Touch"

In the opening paragraphs of his chapter on Forced Technology to High Tech/High Touch (1), Naisbitt states

> High tech/high touch is a formula I use to describe the way we have responded to technology. What happens is that whenever new technology is introduced into society, there must be a counterbalancing human response--that is, high touch--or the technology is rejected. The more high tech, the more high touch. During both the 1950s and the 1960s, we mass-marketed the products of that industrial era--products whose regimented uniformities mirrored their industrial base. High tech was everywhere--in the factory, at the office, in our communication, transportation, and health care systems and, finally, even in our homes.

The urban expressway plans of the 1960s illustrate an obvious attempt to force a new technology beyond ready public acceptance. When we assumed office in 1979, eight major Pennsylvania Interstate urban expressway projects were locked in various controversies. Since 1979 we have withdrawn one from the Interstate system and downscoped and redesigned the remaining seven. Five are now well under construction and the other two will be under construction shortly. This represents some 65 miles of urban expressway and close to $1.5 billion worth of engineering design and construction. In each case, we were successful because we first insisted that there be a local consensus in the design and location and, secondly, because we remained totally committed to constructing facilities compatible with their respective environments and sensitive to the concerns of those citizens most directly and significantly affected.

This process requires considerable interaction with both local officials and private citizens. It also requires creative, imaginative, and innovative designs to address local issues and still provide the basic service for which the facility is primarily intended. For example, in some cases we found that by limiting the number of interchanges we could reduce the number of lanes required--thus, the needed right-of-way was reduced considerably. In another case, high-occupancy vehicle lanes were incorporated into the design. In general, we were able to substitute higher technology but only through extremely sensitive interaction (high touch) with the various constituencies involved. To again quote Naisbitt, "We must learn to balance the material wonders of technology with the spiritual demands of our human nature" (1).

Pocket Calculators to Personal Computers

Another obvious area where high technology has been forced is computer technology. Because of an early awe for electronic brains and artificial intelligence, many people became intimidated by what is a relatively simple machine. There is no need to discuss the dramatic shift that has taken place since the advent of computer games and such user friendly systems as the Apple and the Peanut. But we will point out some of the implications for engineering agencies, again drawing mostly from our own experience.

First of all, the personal computer finally put the computer in its place simply through the creative device of calling it personal. Even though today's personal computer has more storage capacity and operates much faster than the world's largest and fastest computers of just a few years ago, they have now been put on a scale where the individual believes that he or she actually is in control rather than being manipulated by electronic wizardry.

The personal computer can facilitate the entrepreneurial approach to running a large public works agency by aiding in the establishment of adequate control systems for overall monitoring and management. But large central processors and massive data banks are also necessary. We have committed almost $30 million over a 4-year period to enhance our various electronic data processing, or information systems. Major efforts include upgrading the driver's license and vehicle registration system, integration of the various systems related to fiscal management, and integration of the various systems related to roadway management. In addition, we have made a major commitment to computer-assisted design and drafting and office automation. In all cases, because users have terminals at their finger tips, whether it be a time-sharing terminal or a self-contained personal computer, they have more of a sense of being in control.

It might be helpful to provide some examples of how personal computers are now being used. At the district level, all districts will soon be putting their annual county maintenance programs on personal computers. These programs include county-by-county routine maintenance activities such as shoulder cutting, pipe replacing, crack sealing, and so forth--tasks occupying 8,000 employees and consuming $600 million per year. In addition, we expect that most of the districts will soon have their 4-year business plans on personal computers. At the statewide level, we recently developed a pavement management system called Systematic

Techniques for Analyzing and Managing Pennsylvania Pavements (STAMPP). The computer system that supports STAMPP was developed by a pavement engineer in the department. He developed most of it on his own time with his personal computer (PC). Now each district has a computer zealot and a PC to support the STAMPP system and its application to pavement management.

Although not personal in the same sense as PCs, our computer-assisted design and drafting system gives our designers and drafters a greater sense of being in charge. As this system becomes more fully operational, we expect a three- to five-fold increase in productivity. More important, designers and drafters will be free from most of the tedious monotony of their work so that their creative abilities can be applied to innovative design and development. For decision makers, it means that instead of choosing from "either-or" situations, a more sensitive selection can be made from a full array of options.

Big Federal Government to Smaller Local Private Enterprise

The trend in the 1960s and 1970s was toward a larger and more centralized federal government. That trend has now reversed; the federal government is delegating more responsibility to state government and state government is delegating more responsibility to local government. President Reagan made an issue of New Federalism some years ago. Although the formal package never developed, defacto "new federalism" has been in effect for at least a decade. As inflation has decreased the purchasing power of the federal dollar, state and local governments have had to fill the gaps. In Pennsylvania, for example, we recently embarked on a 6-year, $1.4 billion bridge replacement and rehabilitation program. Although the federal bridge program provides for a participation rate of 80 percent overall, Pennsylvania's program is only counting on 50 percent federal aid. Our local problems were so bad that we simply could not wait on more federal support.

At the state level we are returning highways to local governments. Pennsylvania's 44,000-mile state system contains some 11,000 miles, which, by any measure, are local in function. We have recently launched a program to repair these roads and return them to local management. Currently, more than 1,400 miles of such roads will receive attention from more citizen-responsive local managers rather than from the more centrally directed state managers.

Conrail is another example of a large agency shedding itself of burdensome local branches in an effort to regain profitability. Where a more cost-effective local operation could be established, such lines, and the rail freight service they support, have been preserved through local management with state assistance. The Reagan Administration's efforts to back out of providing transit operating assistance offer yet another example. Although the proposal has not yet become a reality, Pennsylvania has been working with its local governments toward enabling legislation that would allow local governments to develop taxation for transit operating expenses.

Another aspect of this trend toward smaller government is manifested by increasingly large shares of government work being contracted out. Over the past 6 years, PennDOT's work with private contractors has been increased almost five-fold from $180.2 million in fiscal year 1978-1979 to an estimated $850 million in the current fiscal year (1983-1984). The belief is that the competitive bidding process will result in more cost-effective work. The exercise of going through make-buy evaluations also puts our own people in a competitive mode so that our force account work becomes more productive and more cost effective. In either case, whether by private contractor or by in-house effort, the result is a more entrepreneurial approach to public enterprise.

From Research to Innovation

During the 1960s and 1970s we got carried away with the Buck Rogers type of transportation research. Probably the zenith of these efforts was the Transpo Exposition held at Dulles Airport in Washington, D.C. during 1972. At that time we were talking about automated highway systems, flying trains, and kneeling buses. Clearly, the problem was not a lack of ideas, but rather one of ideas whose time had not yet come. Although the public may have been receptive to some of these ideas, the economics for putting this technology in place simply did not exist. As a result disappointment turned to disenchantment, which in turn almost led to a complete dismantling of the transportation research effort. Belatedly, we realized that research consumes resources and only innovations in operation hold the promise for savings.

Recently this disenfranchisement of transportation research has been turned around. The efforts of the Transportation Research Board's Strategic Transportation Research study (2) provides one positive example. A proposal has been developed for a $150 million 5-year effort to accelerate the search for highway and bridge innovation. For example, the study recognizes the strategic importance of the fact that as the nation begins to rebuild its highway infrastructure, enormous quantities of asphalt cement will be required. Asphalt was once derived from a few well-known sources that produced asphalt with predictable properties; now new asphalts may come from any place in the world and behave in an unpredictable fashion. The result is that in too many cases asphalt pavements, instead of providing a smooth surface for 10 to 15 years, are coming unravelled in only 2 or 3 years. The importance of this issue is emphasized by the numbers. America will place about $100 billion worth of asphalt pavement in the next decade. A savings of 1 percent would yield $1 billion a year for other purposes.

What are the implications of these trends in transportation and how will they affect education for engineers? We will discuss the implications for education as well as the implications for the transportation industry, but first, let us try to describe the ideal transportation engineer in today's world.

TRANSPORTATION'S IDEAL ENGINEER

The ideal engineer for the 1980s is well grounded in basics and is capable of solving unique problems in creative, imaginative, and "high-tech" ways. The ideal engineer is completely comfortable with modern information systems and is equally at home either working individually or working on multidisciplinary teams. He or she is sensitive and skillful in basic social interactions and possesses good communication skills. The ideal engineer has an understanding of both entrepreneurial reality and the broad social and economic aspects of local, state, national, and even international political structures. Above all, he or she has high moral standards, good leadership qualities, and the ability to manage both herself or himself and others in the pursuit of transportation's social, economic, and environmental objectives.

Perhaps an ideal engineer can be represented by the famous father-son team that engineered the Brooklyn Bridge--John and Washington Roebling. In a recent article in Professional Engineer (3), Florman reports that John Roebling, in addition to architecture, bridge construction, and hydraulics, "studied philosophy under the great Hegel." Washington Roebling in addition to his technical courses, "studied logical and rhetorical criticism, French composition and literature, and intellectual and ethical philosophy." Florman concluded that the Roeblings' "ability to persuade, enlighten, and inspire their fellow citizens contributed as much" to the success of the Brooklyn Bridge "as did their considerable technical talent."

IMPLICATIONS FOR EDUCATION

The implications for the educational system striving to produce the ideal engineer are enormous. All levels of education are affected, and there are ramifications beyond the traditional boundaries of formal education.

At the primary education level, it is important that children with aptitudes for growth in technological sophistication be identified at an early age. These young people should be encouraged to experiment and develop their natural curiosity--to learn on their own. Education should be focused on the individual, and every opportunity should be taken to expose the individual to both nature and science as well as man and society (4).

At the secondary level, greater emphasis must be placed on math and science (5). There should be emphasis on research and experimentation with attention to problem solving. Students should be encouraged to get involved both in their school and in their communities. They should develop an early appreciation for entrepreneurship and gain a sense that they as individuals can make a difference in their community. They should also realize that by working with others the difference can be even greater. They should be encouraged to compete--not only with those around them but with themselves for greater personal achievement.

In higher education the concept of the individual, the notion of ownership, and an appreciation for entrepreneurship should be developed to a fine edge. In addition to a strong grounding in basic scientific and engineering skills, students should be given specific real world projects, both basic and applied. The skills in communications, problem solving, and decision making should be thoroughly developed and applied at every opportunity.

Of particular concern is the need to communicate to young people that they can make a difference. We have a good example from our department of how much difference an aggressive, young entrepreneur can make. We inherited a department with thousands of projects being managed from many different program centers. There was no systematic way of controlling these projects or of monitoring progress toward their completion; so there was little progress. We knew a young civil engineer at Pennsylvania State University who had become interested in computer technology and had made substantial progress on his own in this field. He was willing to leave his graduate program in civil engineering and come to the department to help us straighten out our electronic data processing activities. We talked about the need for a project management system. This young man, Scott Kutz, took this as a personal assignment and by force of incredible individual effort (100-hr weeks) and creative interaction with dozens of people throughout the department, he created a project management system in approximately 6 months.

And by motivating and stimulating people throughout the agency, we built the data base, and quite literally created an electronic file cabinet that now allows us to control projects, control cash flow, arrange our letting schedules, communicate with legislators, and perform a variety of highly effective tasks. Again, all of this was because of one man's zeal and dedication during a very short time period. We need to tell young people throughout their education that great inventions and notable strides toward improvement are usually the result of one committed person or of a person leading a team in our modern society.

With respect to educators, it is critical that they become "facilitators of learning" as opposed to instructors. The traditional textbook-lecture approach must be merged with programmed learning whereby individual students move according to their own skills and at their own pace. At the primary and secondary school levels, some teachers should be encouraged to seek summer jobs in technical environments. In institutions of higher learning, educators should be encouraged to consult and to enter public service.

IMPLICATIONS FOR INDUSTRY

The implications for industry of "new" education in areas of concern to transportation can be discussed in terms of the experienced engineer, the engineer-in-training, the engineering profession, and finally, the involvement of industry itself in education.

For the experienced engineer who has become comfortable in a stable bureaucratic environment over a 10- to 15-year period, perhaps the first step to consider is job rotation. Such engineers should be encouraged to take risks and to develop an entrepreneurial attitude toward their jobs. They should become more involved in their profession by developing and delivering technical papers. They should become more involved in their community's education system. For the experienced engineer whose skills have become stale or obsolete, "restart" training should be provided. For those uncomfortable with the computer, they should be assisted, possibly through a computer loan program. Where necessary, management training should also be provided. In general, the experienced engineer should be encouraged and given wide latitude for personal development (6).

At PennDOT, we have used the rotation technique extensively. Particularly while engineers are in their developmental years, they need to be rotated around the agency so that they can observe the various contributions needed to make the whole agency function. There is nothing more distressing than to see a young man or woman who believes that traffic engineering, for example, is the extent of transportation.

We try to use targeted training for experienced transportation engineers. Each year we perform an extensive evaluation, and as part of that evaluation we outline a program that includes both in-house and external training. Sometimes the training is general short courses, sometimes skills area improvement, but the notion is to make the worker more satisfied with his own abilities and more productive for the department.

For engineers-in-training, it is important to identify the star performers and to do everything possible to put them on a career fast track. Again the entrepreneurial approach is appropriate. People should be given the feeling that they, in a business sense, own and operate the resources assigned to them and have full responsibility for their applications to the problem at hand as well as for the performance that results. Young engineers must learn through experience by taking risks and even by being allowed to make some mistakes. They should be challenged early and brought along as rapidly as their personal development potential will allow.

For the whole engineering profession, it is important to promote engineering and the education required to excel at engineering. A major achievement this year has been the so-called "engineering amendment" to the National Science Foundation Act passed by the House in late April (7). This legislation, recommended by the Engineering Education Task Force (comprised of representatives of the National Society of Professional Engineers, the American Society for Engineering Education, and the National Association of State Universities and Land-Grant Colleges), added an engineering mission to the National Science Foundation's charter.

An example of promoting education required to excel at engineering is the program called MATHCOUNTS sponsored by the national Society of Professional Engineers (NSPE) in addition to the CNA Insurance Companies, the National Council of Teachers of Mathematics, the National Aeronautics and Space Administration, and the National Science Foundation. Only 1 year old, the program, with the assistance of thousands of NSPE members, has already involved 400,000 students from 47 states. Each of the 4,000 participating schools selected "mathletes" who worked their way through state level contests for an opportunity to compete in Washington, D.C. Winners were awarded a trip to Cape Canaveral to watch a space shuttle launch. We, as professional engineers, should encourage and become involved in more such efforts.

For industry, there are numerous ways to support better engineering education. At the primary and secondary school levels, employees should be encouraged to run for local school offices. A speaker's bureau for local schools should be developed so that engineers have the opportunity to describe their profession to budding students. At a recent conference sponsored by the U.S. Department of Education, Pennsylvania Governor Richard Thornburgh noted that partnerships "make the difference" (8). A way to accomplish this is for agencies and businesses to become involved in adopt-a-school type programs in which they form a partnership with a particular school or schools and make special efforts to support each other through exchanges.

In the past few months, PennDOT adopted the Harrisburg Area Middle School. This is a school of about 2,300 young people; most of them live in the city core area where the work ethic and work experiences are lost or at least badly blurred. We have used a variety of techniques, including providing speakers to the school. But more important, we have brought small groups of students (20 to 30) into the department to share experiences in our computer centers, airports, equipment fleet, and in our driver training, giving them exposure that we hope will enrich their total educational experience. The results so far are promising, but certainly preliminary.

Perhaps most important, the engineering-related industries should make special efforts to employ students in summer jobs and through internships. We have brought students into the department in some special ways. At the secondary level, we are developing litter cleanup crews that work under the auspices of the school system to patrol Pennsylvania's highways and help to make them clean and attractive. We borrowed the idea from Oregon, and although it is just beginning, we believe it offers real promise. Perhaps more important for our engineering students is our summer programs for construction inspection and road condition assessment. We have found that we can take students with 2 years of engineering training, give them a 1-week course, and make them into effective construction inspectors. During the past summer we had 248 such students at work. What they lack in knowledge they make up in dedication. Certainly, the idea of developing highly motivated construction inspectors is a problem that has plagued the industry for years. We believe that this approach is helping to stimulate young careers and is providing us talented short-term inspectors as well. Similarly, we train and use summer students to assess pavement condition for our pavement management system.

At the higher education level, industry can make more resources available through cash and equipment contributions as well as through employee involvement. Practicing engineers should be encouraged to become involved in advisory committees for curriculum review and course development (9). They should be encouraged to teach part time at local universities. On the other side, university consultants should be hired and challenged to field test their ideas. The concept of the visiting scientist to industry should be developed for field testing ideas from university research laboratories.

Three years ago, we established a position of visiting scientist with the intent that a university scholar in a transportation-related area would come to the department for no less than 6 months nor more than 1 year to work with us in a program that would be developed in a cooperative fashion. The first visiting scientist stayed 1 year and elected to stay a second year as director of research. The second visiting scientist has been identified, an individual with a strong structural research interest. We are looking forward to a continuation of this positive experience, and indeed, are considering expanding it. The benefits so far are clear on both sides.

SUMMARY AND CONCLUSIONS

In summary, let us repeat our assertion that transportation is too broad and involves too many elements of the environment, the economy, and society to be treated as a single discipline. We must recognize that this function exists in a rapidly changing, highly uncertain world that requires creative solutions to emerging issues and innovative application of advancing technology.

If our country is to remain competitive in the world economy, then there must be a national commitment to excellence in education; in particular, a recommitment to science and technology. Education for transportation can only benefit from such an effort. Such a commitment, however, carries responsibilities: as parents to our children, as engineers to the institutions that educate us, as employers to our employees, and as citizens to our communities--education is everybody's business.

Our objective is to educate creative individuals who are not afraid to take on a problem and solve it, individuals who develop entrepreneurial ownership for their ideas and pursue them even though the risk of failure may be great, individuals who interact with others so as to remain sensitive to both the individual and collective needs of society, individuals who welcome new challenges in a world of change.

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Training Requirements for Transportation Technicians and Technologists

Donald L. Woods, A. Nelson Evans, and Charley V. Wootan

Several forces have acted to raise the need for technicians in transportation to increasingly higher levels. Shrinking real dollars in transportation budgets have moved transportation professionals into broader analytical and management responsibilities. Inflation and conservative legislatures have held down the transportation work force and incentives to young professionals. The volume of work has changed to reflect more manpower-intensive projects due to budget and environmental pressures and the need to get better utilization from existing facilities and to avoid replacement or costly expansion. Transportation agencies are facing growing demands and a shrinking trained work force.

THE TRANSPORTATION TEAM

The role of the various members of the transportation team is not rigidly structured. There is, however, general agreement on the scope of the responsibilities of each member.

- Transportation Technician. An especially trained individual who conducts routine duties that require considerable skill and judgment. This will include duties that are repetitive in nature.
- Transportation Technologist. A graduate of a 4-year academic program in transportation technology with special emphasis on the application of transportation principles. The training and experience of the individual enable him or her to do most basic transportation design and make fundamental operations decisions.
- Transportation Professional. A graduate of a 4-year accredited program in transportation. This training equips the individual to solve special technical transportation problems, to make transportation trade-off decisions, and to manage the transportation team.

In the highway engineering field, examples include the following job descriptions:

- Technician: Routine soil and materials testing and quantity takeoffs from the cross sections.
- Technologist: Geometric design, cross-section design, and basic decisions on alignments provided by the engineer.
- Professional Engineer: Selection of alternative alignments to be examined, social, economic, and political trade-off decisions; and cost-effectiveness analysis of alternatives.

Although there is a wide variety of application of the individual skills within specific agencies, this structure has proven to be both economic and technically workable. In this paper the role of the technologist and advanced technician in the transportation profession is addressed. The term technologist is used to encompass this broader definition of technician and technologist.

The investment required to produce trained technologists is considerably less than for transportation professionals, and the salary requirements are lower. Many functions performed by professionals in the past can now be performed by properly trained technologists. Why? Because of the availability of high-speed computation and decision-making capability on routine matters.

The advent of the mainframe computer connected science and practice. The development of the microcomputer transferred much of the routine technical work previously being performed by professionals to the transportation technologist. Analytical computation, once the domain of the professional has, in a very brief time, been relegated to the technologist. Professional work is no longer how to do something, but rather what the results mean after the computer delivers the computations. Computers, even the relatively small ones, are capable of performing the computations needed more accurately, faster, and at the time the professional needs them. The bulk of engineering computation is now being accomplished on the computer. The transportation technologist is taking over the performance of analytical computations, leaving the decisions on special cases and interpretation of the computer results to the transportation professional.

There are many in the transportation profession who believe this is a bad trend. They believe that persons without a true understanding of transportation principles are cranking out specific solutions to transportation problems on the microcomputer; this is true. The challenge to all of the transportation and technology educators is to teach the proper use of the microcomputer's capability. Instead of viewing this emerging microworld as a challenge to the transportation profession, the authors believe that it frees the transportation professional to do the creative work for which transportation training best equips the individual. Only a very narrow view of transportation would consider the tremendous number of computations required in the past as professional work. These computations were simply tools needed to reach a solution to a problem. The microcomputer frees the professional from these laborious computational tasks. Once the computer program is written, it enables the professional to examine 10, 20, or even 100 different alternatives in order to produce a suitable and economic design. The microcomputer has substantially expanded the role of the transportation professional to better meet the needs of society.

To effectively use the current computer capability skilled operators are required. They must understand analytical computations and the operation of the computer. The trained technologist fills this role. Just as the technologist replaced the engineer in laboratory testing of soil, materials, and water quality, so will routine transportation design become the domain of the technologist. The transportation professional will become more decision- and management-oriented.

ROLE OF TECHNOLOGICAL CHANGE IN TRANSPORTATION

The change in basic disciplines such as transportation will be far more dramatic than in the other analytical fields for two reasons. First, the nature of the overall transportation function has shifted. Transportation agencies were created and experienced their periods of major growth in the "build" mode. In this mode, standards were developed and substantial uniformity evolved. A given type of roadway had certain standard requirements of design, and only a limited number of design alternatives had to be evaluated. The current "maintenance-rebuild-add on" mode in which new capacity is added to older facilities by upgrading of existing roadways instead of building new facilities on new right-of-way is the common rule. Each project is unique with a large number of options to be evaluated; each requires computations and analyses suited to the computer.

Second, computerization of the newer technical specialty areas came first because of the concentration of manpower and the relatively large projects on which these professionals worked. This made mainframe computation practical. The more basic human needs-oriented areas were traditionally scattered in relatively small professional groups which, at best, had to share computation capability and were dependent on others for getting the work accomplished.

The lack of responsiveness of the mainframe computer operator to the special needs of the professional, combined with the high cost associated with the purchase and maintenance of a mainframe computer, limited the application to special needs that could not be accomplished by other computational procedures. The microcomputer provides the computational capabilities needed by the transportation professional at relatively low cost. It effectively brings to the transportation professional the full benefit of the computer.

RESPONSIBILITY OF THE UNIVERSITY

The role of the university or college in this process is to:

1. Provide the expert training to help the technical schools adequately prepare their students to serve and supplement transportation professionals.
2. Transfer new ideas, research findings, and demonstrated techniques from research and development to training and implementation.

The first of these responsibilities stems from the limited monies available for transportation education and the ever increasing cost. The result will tend to force technical training out of the university and into the smaller colleges and technical institutes. Research, on the other hand, will remain a major responsibility of the university. Usually the need to transmit the new technology to the center where the technologist is trained will become more critical as the information base expands.

There will also continue to be a large body of practicing technologists who need and must obtain the most current technical information. A high percentage of this need can be satisfied by updating the computer software that the technologist uses. There will also be a continuing need to teach both the practicing technologist and the transportation technology educators the meaning of the computer output: which data are meaningful and which are nonsense. This role will become even greater as we move further into the information age. More people must be trained to a higher level of technical competence. The magnitude of this need is still unknown, and the number needed is still probably grossly underestimated. Industry (some have recognized) must allocate more of its budget to training if America is to become competitive.

In summary, the transportation profession will, or has, changed more toward a management and a technical decision-making role. Routine duties that previously were in the domain of the professional are rapidly becoming the work of the technologist. The trend of the duties of the transportation professional is more toward project management, research, and technical decision making.

TRAINING NEEDS IN TRANSPORTATION

There are two fundamental needs for training in the transportation field: (a) technical training to prepare the potential technologist for initial employment in the transportation field; and (b) retraining current transportation technologists, and those who transfer from other fields, to serve critical or specialized needs. This training must come from (a) in-house training provided by the employer, (b) equipment manufacturers' special training, (c) technical organizations, and (d) technical schools.

A combination of the training provided by all of these sources will be required to meet the needs created by the expanded role of the transportation technologist in the next decade.

SCOPE OF TRANSPORTATION TECHNOLOGIST TRAINING

The areas of training for the general civil engineering technologist have been identified by The National Institute for Certification in Engineering Technologies (NICET) (1). These needs include the following:

- General Skills
    - Communications skills
    - Mathematics through pre-calculus
    - Microcomputer use
    - Personnel management
    - Vehicle fleet management
- Civil Engineering Skills
    - Concrete mix design
    - Highway design
    - Structural design
    - Mapping and photogrammetry
    - Inspection and materials testing
    - Environmental analysis
    - Surveying
    - Foundation design
    - Blueprint reading
    - Soil analysis and testing
    - Cost estimating
    - Materials inspection and testing
    - Construction equipment use and functions
    - Excavation and fill computations and planning
    - Drainage design for highways and streets

[Note that microcomputer use, personnel management, and vehicle fleet management were added to the NICET list by the authors.]

The engineering-related transportation speciality area requires some skills not listed in the basic NICET skills list. These special training needs in highway engineering subspecialization areas are as follows:

- Highway and Street Design
  - Structural concrete design and detailing
  - Structural steel design and detailing
  - Pipe and drainage structure design
  - Hazardous waste transport and safety
  - Stabilized base materials
  - Intersection design
  - Pavement design--portland cement and asphalt cement
  - Overlay design and pavement rehabilitation
- Surveying, Mapping, and Field Location
  - Electronic surveying (EDM)
  - General surveying
  - Drainage area measurement
  - Quanity estimates from aerial photographs
  - Computer mapping
  - Structure location and elevation controls
- Traffic Control
  - Traffic control systems layout for construction and maintenance
  - Transit route planning and bus stop location
  - Hazardous waste transport and safety
  - Traffic signal design and plans preparation
  - Solid state electronic circuits
  - Intersection design
  - Traffic control principles
- Construction and Maintenance
  - Aggregate sampling
  - Traffic control layout for construction and maintenance areas
  - Hot-mix installation techniques
  - Mixer drum operations
  - Portland cement pavement design techniques
  - Pipe and drainage structure sizing
  - Pothole and pavement maintenance techniques
  - Trenching safety
  - Stabilized base materials
  - Hand-tool and power-tool safety
  - Hazardous waste transportation and safety
  - Herbicide and pesticide use and safety
  - Safety practices for in-the-road maintenance
- Public Transportation
  - Transit route planning
  - Transit operations and evaluation
  - Bus maintenance programming and scheduling
  - Fleet management principles
  - Transit marketing
  - Public attitude surveys and rider interviews

Transportation technician and technology educational programs will need to be general enough to allow employment in any transportation mode and yet specific enough that the technologist will be fully functional on the job. The specific mix of courses will, by necessity, be different for each institution.

ESTIMATED DEMAND FOR TRANSPORTATION TECHNOLOGISTS

The number of transportation technologists that may be needed in the various levels of government in the coming decade is unknown. A ballpark estimate based on the authors' perception of the present employment trends and expectations for the future role of the technologist in the transportation field suggests the need for highway and street design, traffic control, and construction and maintenance technician and technology programs in every state. The remaining speciality areas will probably be regionally focused.

SUMMARY AND CLOSURE

The changing nature of transportation suggests that the bulk of the routine transportation tasks of the past will, in the future, be accomplished by transportation technologists. The economy and the technical capability favor a greatly expanded technician and technologist role in transportation in the next decade.

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Education Requirements for Transportation Consultants

Wilbur S. Smith

For the purpose of this discussion, it is assumed that the type of education primarily being considered at this conference is related to college studies leading to a bachelor of science degree. The papers interestingly cover not only what is being taught, and might be taught, but also what consumers want. This discussion is aimed at training for transportation consultants. However, the more the subject is considered, the more it appears that the training for transportation consultants is not basically different from that desired for all types of engineering consultants.

The ideal in recruiting transportation consulting personnel would be to locate people who have all of the educational backgrounds described in all of the other papers presented at this session--and more. Obviously, this is not reasonable and, perhaps, not possible.

WHAT IS TRANSPORTATION CONSULTING?

It is necessary first to consider what is encompassed in transportation consulting. Although there are some highly specialized transportation consultants in the United States, most of them engage in a broad array of services. Consultants are not usually needed unless (a) the problem is unduly complex; (b) special talents or experiences are required; (c) the magnitude of the job exceeds the capabilities available in-house; or, (d) third-party inputs are desired, or are required.

In transportation engineering consulting, there is almost no limit to the number of opportunities to use different professionals. It is not uncommon for such firms to offer services in planning, marketing, economics, safety, management, economic feasibility, environment, public transportation, computer software, and other areas in addition to conventional engineering disciplines. Within these organizations, it is natural to find an interesting mix of engineering backgrounds. Professional staffs consist of most types of engineers, and these range in educational backgrounds from baccalaureate to doctorate degrees.

The breadth of engineering is reflected in the manner in which the National Academy of Engineering groups its members:

1. Aeronautical/astronautical engineering,
2. Agricultural engineering,
3. Chemical/petroleum engineering,
4. Civil engineering,
5. Electrical engineering--communications/computers/control,
6. Electrical/nuclear power engineering,

7. Manufacturing engineering,
8. Mechanical engineering,
9. Mining/metallurgy/ceramics/materials engineering,
10. Operations research and industrial engineering, and
11. General engineering.

Some consulting firms are of sufficient size and have such diversified work loads that they need individuals who collectively have had training in all of these areas.

Over a period of about 35 years, Wilbur Smith and Associates has grown to an organization with more than 500 permanent employees. We still consider ourselves transportation consultants. Our marketing brochure lists the following areas in which we believe we are qualified to offer professional services:

1. Air transportation;
2. Architecture;
3. Design and construction management;
4. Economics;
5. Energy systems;
6. Environmental impact studies;
7. Financial feasibility studies;
8. Industrial development services;
9. Marine facilities, ports, and waterways;
10. Marketing;
11. Parking and terminals;
12. Planning;
13. Public transportation;
14. Rail transportation;
15. Research and development;
16. Systems analysis and model development;
17. Transportation planning;
18. Transportation safety;
19. Truck transportation; and
20. International.

These areas break down into approximately 130 subactivities. Consulting firms are unable to find all of the knowledge and resources that they would like to have in a single person. When they reach a relatively small size, consulting firms are likely to require teams to provide adequate services for most of their projects--teams made up of a number of disciplines and containing people with high levels of expertise in some disciplines. Putting all of the talents together as an effective team is the challenge.

Most consulting firms do not grow because they want to "be big," but, because in engineering consulting practices, there are strong tendencies toward peaks and valleys in availability of work. To a great extent, these peaks and valleys can be overcome, or minimized, if the firm is sufficiently diversified and personnel can be shifted from one field to another.

After periods of continuing growth, a transportation consulting firm might reach a certain size and become so diversified that the term transportation is dropped. Emphasis can be on transportation, or transportation can be just a part of total services offered--one ingredient in a mass of consulting activities. But discussions here relate more to the qualifications and educational needs for those who are primarily in transportation activities.

Transportation engineering is perhaps more likely to be subjected to rapid changes in technology and demands than some of the founder engineering disciplines. Transportation has always been an important part of civilization, but our modern era of transportation (as it is normally perceived in consulting work) began with the railroads and waterway facilities. It expanded rapidly with the advent of the automobile and with public transport, typified by street cars and buses. Then opportunities came along in the field of air transport, and this has offered a rapidly developing opportunity for transportation consulting. All of the new transportation modes required terminals and extensive and innovative methods of finance. We are now on the verge of space transportation. When our government sends into orbit space laboratories and space platforms, the shuttle, for example, will become primarily a transport vehicle carrying equipment, supplies, people, and perhaps products to and from these types of facilities and earth.

The term transportation consultant is broad. Most of the consulting engineering firms that specialize in transportation offer a broad spectrum of engineering services. Therefore, this paper is intended to emphasize the educational background transportation consultants desire for engineers. However, this does not minimize the importance and opportunities for those in other disciplines.

Transportation engineering, particularly in consulting practice, has some characteristics that are different from the more conventional, longer established engineering areas. In consulting, an individual must be willing to do everything possible to satisfy the wishes and demands of clients, including excessive hours of work, additional study, and research off the job in order to apply the very best experiences to the job at hand. In most consulting practices, the professionals are required to travel extensively. This travel might even be international. This, in turn, means a willingness to be separated from family for rather lengthy periods of time and a willingness to include in the work schedule a substantial allowance for business travel after or before a normal work day begins. Perhaps these are not characteristics that would be called training, but, in many cases, the educational institutions can be helpful in conveying to students these characteristics with their own evaluations.

GENERAL OBSERVATIONS ON EDUCATION

Consulting engineering firms need individuals who have a broad spectrum of talents. They need the traditional talents and they need people who are innovative. It is generally agreed that innovation cannot be forced, but it can be fostered by universities and by employers. Consulting engineering firms prefer individuals who are willing to cooperate and help move the firm forward by offering new and more marketable services. In consulting, growth is essential. The consulting firm, therefore, wants men and women who have ambitions and who have high personal and professional goals.

In personal qualities, discussions go beyond the responsibilities of educators, but all consulting firms, and for that matter all businesses, are very much interested in knowing something about the basic qualities of the engineers they employ. They know that the quality of the student is an important factor in where the student is going and how he or she plans to get there. Educational institutions can provide useful information on how students are selected.

Consulting engineering organizations are businesses. In most instances they must make a profit; therefore they need people attuned to the business side of their activities to be concerned about such items as overheads, profits, budgets, schedules, salary ranges, and so forth. One or more courses in business administration would be desirable.

Consultants, perhaps more than those in some other businesses, need to constantly look ahead for new and changing markets. A talent for selling or marketing is valuable among employees. It follows then that business courses in marketing would be helpful.

A conference of this type may appear to be minor, but consultants can have deep concerns about the inability of engineers, and other professionals, to express themselves in both written and oral communication. Practically every consulting job requires reports, and the results of the consultant's work in most cases is heavily dependent on the manner in which these reports convey findings and recommendations. Clear, concise report writing is essential. Engineers should know how to write coherent, articulate reports and how to personally present their findings and recommendations.

Civil engineering courses appear to offer the best background for undergraduate training for transportation consultants. Such courses offer a highly desired variety in engineering education; they permit a greater opportunity than most engineering disciplines for electives so that basic courses in such areas as traffic operations, traffic control, and transportation economics can be inserted.

Most U.S. transportation consultants are active in international projects overseas. There are interesting opportunities for transportation consultants abroad, and this can have an important influence on the makeup of some of the firm's personnel. In addition to what engineers, or other professionals, might have learned in basic education, if they are to be proficient in international work, they need to know about international regulations and controls. This would include such subjects as foreign exchange, taxation, regulations of professional practice, and risks that are peculiar to working in other countries. Curricula in these areas would be helpful. Today, most of the larger colleges and universities offer a variety of courses in international studies that could be valuable to a student entering transportation consulting practice.

Some engineering schools increasingly are providing greater opportunity for students to study in and co-mingle with students in other parts of the total university; they are encouraging students to pursue a broadly based educational experience. This approach offers engineering students essential modes of thought to better deal with wide varieties of human issues.

In engineering at Duke University, about 50 percent of a student's total undergraduate effort is in what are normally considered to be nonengineering courses. The training in nonengineering courses offered at Duke appears to be about double the amount permitted and required in many other fine engineering schools around the country. This type of broad training can be valuable to consultants.

Special training for transportation engineers, or transportation specialists, appears to be more a matter of training students in the best means of bringing the general (and broad) knowledge of engineering and related courses to bear on transportation needs and transportation issues.

However, where high specialization is required in transportation employment, or careers, it appears desirable to provide this specialization at the graduate level rather than in the undergraduate curricula. There are so many courses available at the graduate level that there is little need to attempt to describe the courses that should be offered. Whatever specialization is required of transportation consultants, it is almost certain that they can acquire the appropriate courses in the standard graduate curricula.

The question might be asked: Where does proliferation of training needs for engineers end? This is not an easy question to answer because events are always occurring to change the status quo. In a recent article in Consulting Engineer (1) it is pointed out that a somewhat alarming court decision has recently been rendered in the state of Kansas. The court ruled that, unlike medicine and law, engineering is an exact science and that engineers may be treated as ensurers of a result (i.e., libel even without proof of negligence). The court ruling states that "(a) person who contracts with an architect or engineer for a building of a certain size and elevation has a right to expect an exact result." Changes in conventional understandings of liability responsibilities and the general attitude that prevails in current society to "blame everybody else" suggests that engineers are one of the professional groups that can be highly vulnerable when anything goes wrong or can be assumed to go wrong (1). Do transportation engineers need legal training? Where does the proliferation of educational needs end?

OTHER TRAINING CONSIDERATIONS

In the United Kingdom, the belief for a long time has been that, to make the best use of graduate engineers, it is essential to have adequately trained technicians. The recognition of this belief has been so far-reaching that a joint training scheme for civil engineering technicians is run by the Institution of Civil and Municipal Engineers, the Association of Consulting Engineers, and the Federation of Civil Engineering Contractors in London. These groups stress that the objective is to train technicians to support professional engineers; they recognize that technicians and professionals are all a part of the team and that they must work together for each to be most effective. Principal subjects covered in the training are broadly categorized as (a) traffic investigation and transportation studies, (b) traffic engineering techniques, and (c) overall administrative and management considerations for technicians.

Many states now have well-organized technical training schools (which I believe in most instances have training levels comparable to junior college). Emphasis is on vocational training, but standard basic courses are offered also. Credits for completing the courses are transferable to college credits in most instances. This is timely. Transportation consultants would like training of this type to continue because it is important for maximum overall productivity.

In-house training is always an important consideration in the plans of consultants although it becomes extremely difficult to fit it into active businesses. Many of the training needs of consultants are provided, however, through various types and forms of in-house training programs.

Increasing information in handbooks reduces some necessity for detailed training in transportation. Once the engineer has information available in handbooks, he is normally able to apply it to transportation problems and issues, whatever his basic educational background.

CONCLUSIONS

Understanding the inner-connectives in transportation might be more important to the transportation consultant than understanding too thoroughly each of the individual pieces. Thirty or 40 years ago, a professional was likely concerned with such relatively simple tasks as planning traffic signals and the erection of signs. Today, the professional is in the midst of very complicated planning, design, and management of projects. Under such circumstances, it is easy to understand why some young professionals who are entering the field of transportation consulting might be confused by the great breadth in diversification in opportunities. The smorgasbord of professional activities and opportunities can to a degree be overwhelming. These situations can be overcome by giving full attention to personal achievements and advances and also to advances in the overall interest of the profession.

Cutting across many scientific and technical disciplines, the transportation engineer might be called an interdisciplinarian. His activities are totally entwined with those of others. He has to learn to work effectively with planners, economists, mathematicians, computer experts, systems analysts, and others who have a substantial interest in and special talents or solutions to ever-growing transportation problems.

Consultants usually need a cross section of all engineering, plus a number of other disciplines in order to take advantage of the many and diverse opportunities in the broad field of transportation. It has been well stated that "education offers the tools--basic skills and disciplines--but success requires self-knowledge, ambition, and personal goals." More specifically:

1. Needs vary greatly with the scope of services offered by the consulting firm and with the size of the firm. Big firms can afford to employ professionals who have become highly specialized in their college education such as computer engineers, geologists, environmentalists, market analysts, and safety engineers. Both the small and the large firms need professionals who have had more generalized training courses, such as those offered in civil engineering, economics, business administration, and planning. They need a backlog of engineering generalists. Specialization in these courses may or may not be desirable.

2. Within the formal college curriculum for engineers, it appears that the basic technical education provided is satisfactory to meet the general needs of transportation consultants. It must be recognized, however, that it is not possible to complete in a 4-year period some of the materials that might be included in curricula for engineers.

3. Where there is flexibility in the curriculum, the transportation consultant would like courses in the following areas inserted: business administration, marketing, communications, and international issues.

4. For transportation consultants, it is highly desirable to have individuals who have not only received basic technical engineering educations, but who also have considerable knowledge in communications, computer applications, and also in socioeconomic and political relationships that interface with engineering and transportation. Engineers who have a high level of training in nonengineering courses are generally preferred by transportation engineering consultants.

5. Outside the scope of training courses, the consultant is interested in the basic standards for admission to a given educational institution. In addition, they would like to have students who have, in some way during their college

career, been told frankly about the advantages and disadvantages of consulting practice.

6. Changes are occurring rapidly and each generation of engineers is likely to be different from the last. Changes in transportation engineering are occurring at a very rapid rate, and this should continue for many years into the future. There can be no status quo in training needs.

7. Consulting organizations can make engineers and other professionals more effective because they have available resources of trained technicians.

8. In-house training programs are especially important in transportation consulting because of the large number of variables in the work and the unusual conditions that arise.

9. Civil engineering appears to be the best course of study to produce transportation generalists that are needed by consulting firms of all sizes. This is the training that should be emphasized at the undergraduate level. Courses in both engineering and nonengineering subjects sought by some consultants should be provided at the graduate level.

In highly specialized consulting firms, there are likely to be notable deviations from the requirements enumerated previously because these requirements are intended to relate to medium to large firms.

Because it is not possible to expand or greatly change the curricula of most engineering courses, it might be advisable for universities to emphasize to students the need for continuing education when they enter transportation consulting. Encouraging students to participate in professional conferences, including the preparation and presentation of technical papers, and to become a part of the transportation profession as soon as they are qualified can be valuable to consulting organizations.

REFERENCE

1. J.F. Forster and D.A. Ostrower. Engineering: An Exact Science? Consulting Engineer, Sept. 1984, p. 70.

What Are Shippers and Carriers Looking For?

Gayton E. Germane

First, let us refine the question "What Are Shippers and Carriers Looking For?" I have interpreted this to mean ". . . When Looking for Applicants for Entry Level, Management Positions." This, I believe, is the market that most of us from the academic community are especially interested in because it is the market for which our students are preparing. A further consideration is the time horizon involved. The organizations are looking for entry-level management personnel, but the firms are also hoping that they will be able to select people who will have the ability to become senior executives in later years. Thus, what the shippers and carriers would like to find is a here-and-now set of qualifications, and a later-years prospect of substantial advancement and responsibility in the organization. These are the criteria that should be kept in mind in considering the views that will be expressed in this paper.

This paper is based in part on the views and experience of a number of outstanding senior executives from rail, highway, and water transport, and from the shippers. The purpose was not to determine the general view, but to obtain the best advice and guidance on the question: "What Are Shippers and Carriers Looking For?" This was a series of views, selected for excellence, in terms of the background and performance of the spokesmen. They will not be identified, but some examples from their experience will be noted in this discussion.

I have been fortunate to know well a number of capable senior executives in the various modes of transportation. This was one of the advantages of my 13 years in the Transportation Association of America, as Chairman of the Coordinating Committee and as Moderator of the Cooperative Project on National Transportation Policy. In these activities, I became well acquainted with the leaders from four modes of transportation, plus users and investors with special interests in transportation. This led to many exchanges of candid and informal views individually and within groups. It is this background, supplemented by some specific recent questions to many of these executives, that has shaped the views expressed here. Let us turn now to a discussion of customer preferences or market demands.

SELECTION CRITERIA

Carriers and shippers generally have very definite ideas about what they want, but sometimes find it difficult to evaluate accurately the real attributes of the persons being considered. This is in part a result of the need to use indirect measures rather than direct evidence of the qualities sought.

For example, it was generally believed among my acquaintances that the following characteristics were important among the desirable qualifications. They believed that the prospective entry-level management person should be

- Intelligent,
- Industrious,
- Personable, and
- Should have the necessary basic knowledge and skills.

Intelligent apparently meant quick to learn and also having considerable common sense. Intelligent was inferred from grades in school, honors and awards, and so forth. Common sense was evaluated by response to questions in interviews and also by the questions raised by the applicant. Recommendations from previous supervisors and employers were also weighed, along with work experience and results achieved, in seeking to evaluate the quick to learn and considerable common sense characteristics.

Industrious was a characteristic that was judged from the applicant's work record and recommendations, and to some extent from academic grades. For example, a conclusion might be "If he made grades as good as that, and worked part time at the plant, he has got to be intelligent and industrious."

Personable appeared to mean that the individual made a good appearance and conversed comfortably with the interviewers. References often mentioned special qualifications in this regard, but personal observation by the interviewing team generally carried the most weight.

Basic knowledge and skills were generally evaluated by the nature of the courses taken and the work experience of the applicant. However, the response to questions during the interveiw might cancel the impressions given by academic criteria and previous employment. For example, a personable young man, with a graduate degree from a prominent university, disqualified himself totally with the chief financial officer of a steamship company when he gave a vague answer about how he would interpret a coefficient of correlation of +1.25. Because the possible range is -1.00 to +1.00, it was clear that the applicant was missing some basic concepts that even an average student should remember, given the courses allegedly taken by the candidate.

The Decision Process

The cross checking of grade performance, telephoning of references, presentation of recommendations, verification of work experience, and discussion by several interviewers of their impressions, is a general practice. This usually leaves the prospective carrier or shipper employer with a strong impression of an applicant's capacity. If that impression is strong and favorable, then the firm has an acceptable prospect. If the impression is less than strong and favorable, the applicant is not likely to be offered a position with the firm. Although this whole process deals with indirect measures of the qualities sought, most of the executives I have talked with are comfortable with the ability of their organizations to make selections on that basis. The important difficulty is not in selecting to meet the requirements of the entry-level management positions, but in evaluating the probability of future development; that is, the potential for promotion to senior management in the years ahead.

PROSPECTS FOR SIGNIFICANT ADVANCEMENT

Among the military officers I was fortunate to know well was the former chief transportation officer of an overseas theater in World War II. Some years ago, when I was in the Defense Department, I asked him, "When you served on general officer selection boards, what did you look for in reaching your decision?" His reply was as follows:

> To get to the Selection Board, every candidate had to have good efficiency reports so that was not likely to be a crucial difference. I always looked first to see if the candidate had several Commendations in his record. That's essential. We must have senior officers with initiative and imagination. Then I'd look to see if he had any Reprimands. If there were no Reprimands, I would be very concerned. it probably meant that we had there a smart, play-it-safe, SOB who would never take action on an idea or opportunity unless it was a "sure thing." We can't afford that approach at the General Officer level. There are too many decisions that are not "open-and-shut" matters. You have to take risks to win in combat. The officer that will get my enthusiastic support for stars is one whose record includes a good many Commendations and a few Reprimands, in addition to all of the relevant schools, command and staff experience, interservice assignments, etc.

In talking with my friends in commercial transportation and user enterprises, I found a similar concern about determining the qualities needed for senior executive positions. Putting their views together, most of the considerations appeared to fall under three headings: determination, imagination and initiative, and judgment. My business sources believed that these were qualities that were hard to evaluate by interviews, preemployment qualifications, and records. They believed that they had to watch the person grow, work under difficult conditions, or rise to seize opportunities in order to get a good sense of the existence and extent of these particular qualities. They also recognized that in part these qualities were developed by experience. In any event, they were hard to assess without specific examples, and they generally required management assignments in which the necessary challenges were likely to arise. Thus, a member of management probably would be moved along and tested at several levels of authority over a period of years to determine his or her responses. Good performance at one level normally lead to promotion to a higher level. In the following paragraphs are some examples of these tests or events that contributed to qualification for fast-track promotions, and ultimately for senior executive positions.

DETERMINATION

This may be one of the easier qualities to identify in young management personnel because opportunities to observe the presence or absence of determination are not rare. Here are some examples I have heard about that illustrate this extra drive to get the job done. When the individual worked alone, this attribute was often referred to as guts, but when he worked as a team leader, it was usually called leadership.

Railroad

A young railroad attorney was assigned to handle a series of line abandonment cases scattered over the West. He was determined to win and worked hard to understand all the details of each case. He conducted an intensive study of crops and harvest patterns and of agricultural and other traffic services and rates. In the process he became well acquainted with many key people and business prospects for the railroad. His determination and field work paid off and he won nearly all of his abandonment cases. This received attention. His broad knowledge of the regional economics and his information contacts in the area soon made him one of the leading business strategists for the railroad. He ended his career as chairman and chief executive officer (CEO), and the principal architect of the carrier's diversification and profit improvement programs.

Ocean Shipping

The new employee had been hired by a reluctant executive because the young man had some background in marine engineering. An early special assignment was to get an ancient chartered ship running again. This took him from the air-conditioned U.S. headquarters to an anchorage off Saipan. He worked on the old rust bucket for nearly 2 weeks in 110-degree heat with two native helpers. He vividly remembers sweating in the filthy engine room, armed with a Stillson wrench and an oily rag, and wondering if that was what he had earned two graduate degrees to do. His determination and success were appreciated, and he was considered to have paid his dues to the organization. With continued success, he later became executive vice president of the steamship company.

Shipper

A young transportation specialist was assigned to work on the problem of iron ore freezing in the railroad hopper cars. The railroad operating staff and the user plant personnel had no satisfactory explanation or remedy. The young specialist's determination to understand the problem required a great deal of work, but resulted in both an immediate remedy and a long-term solution for the problem. In any event, he advanced in a series of promotions and became chairman and (CEO) of a large firm.

Note that in the last two cases the subject not only showed determination in getting a difficult job done, but possibly benefited from the dramatically unpleasant working conditions that drew extra attention to the results.

IMAGINATION

Shipper

A group of college students, working under the direction of the logistics staff of a large integrated paper company, developed a novel plan for moving paper products on the West Coast. It included a piggyback train to run overnight to a transfer point near Los Angeles. There, the containers would be unloaded sideways into flatbed trailers parked parallel to the tracks. The trucks would make direct deliveries to major paper product customers in the greater Los Angeles area, or to warehouses. A reduced southbound rail rate would be available to the paper company because it would organize a return load for the train from various trucking operators who had empty trailers returning northbound. The empty trailers would be parked on the other side of the train and could be loaded as soon as rail cars were available. Double decking of empty paper product containers on the train was feasible so there would be plenty of train space for empty truck trailers.

While this load exchange was taking place, the locomotive set would refuel, receive a new crew, change ends on the train, and be ready for the northbound trip. This plan would provide high equipment utilization and good loads in both directions for the railroad. The paper company would be able to match the speed and convenience of truck service southbound, at less than truckload costs, and would also reduce its warehouse space requirements in Los Angeles as a result of the direct-to-customer deliveries. This kind of innovation had given the paper company logistics group a strong position in the company and considerable individual recognition. For the logistics group, imagination and innovation were identified with personal success.

Trucking

An interesting example of imagination applied to operating equipment was provided by a young marketing manager with a midwestern trucking company. He was concerned about the low profitability of the large volume of business from a manufacturer of small gasoline engines. On investigation, he found that truck competition was severe for the traffic and that the freight was high density. Because of the small engines' irregular upper surfaces, it was impractical to load other cargo on top of them. His imaginative solution was a movable second deck, or adjustable additional floor, for trucks in this service. The second deck could be secured so that it just cleared the loaded engines. Then, low-weight, high-cube cargo could be loaded on the second deck without damage in transit. The result was that nearly two truckloads of earning capacity could be generated in the same one-truck trip. When the second deck was not needed, it was secured next to the roof of the van. The cost of the second deck was minor, and the reduction in cargo space was negligible. This idea, and other noteworthy innovations, led to early promotion of the young marketing manager.

Ocean Carrier

The steamship company computer services group had been working on a central system to plan and control all container movements in several marine terminals. Unfortunately, the computerized system was less than half finished, but was already more than 2 years behind schedule and over budget by a huge amount. As a kind of insurance policy against further delays, one young operations executive suggested to his vice president that he be given 1 year, a couple of young terminal management staff members, and be permitted to hire a couple of programmers--to see if this little team could develop a system using a personal computer.

The outcome was a highly successful computerized container-terminal operating system. It provided on call, historical data, current operating information, or future plans ard contingency arrangements. Physical layout and space availability were shown in color on a video screen. The computer also optimized container loading and unloading sequences to take account of necessary in-ship positions, and on-land locations and stacking, to minimize total elapsed time. The results were better than anyone had expected, including the innovators, and the project was completed ahead of schedule and under budget. Of course, the young operating manager was promoted and had the pleasure of seeing his system adopted throughout the company. Note, however, that if he had failed, it is likely that those he had embarrassed would have ensured that, at a minimum, his career was severely handicapped.

JUDGMENT

Here are some other examples of young management personnel who "passed the test" by demonstrating good judgment to a degree that warranted consideration for further promotion.

Ocean

A young woman in the finance department of a large steamship company had shown a great deal of competence in various financial planning, management, and negotiating assignments. As an additional responsibility, she was given the task of investing short-term cash balances from various accounts. At first, her results were a source of surprise and satisfaction to senior officers that she had been so lucky. However, as time passed she built a record far better than many of the investment firms specializing in the field. Her superiors became convinced that her performance was a matter of extraordinary good judgment. Additional funds were placed under her control, and she continued to produce astonishing results--to the degree that senior officials needled their banking and investment friends to try and match her. With her performance record well established, the only question now is whether she will receive substantial advancement within the organization, or in another firm. Her proven judgment has made her a standout in the field.

Railroad

This is a case in which cutting back on business was a demonstration of outstanding judgment. A young railroad intermodal official was in the midst of a complete rebuilding of his railroad's principal piggyback yard. In anticipation of increased capacity and service improvements, he had also recently completed negotiations to handle a large percent of the intermodal container traffic for several large steamship companies. Then one of the worst storms in years broke in the mountains. At first, it shut off nearly all rail traffic. When the storm cleared and the backlog of traffic was pushed over the passes, it resulted in the delivery of about 10 days' traffic volume in 2 days. With the new facilities not yet completed and much of the old layout removed, the intermodal yard was in danger of becoming so jammed that movement in or out would be almost impossible. The young executive promptly went to his new big steamship accounts, explained the situation fully, and canceled most of the new arrangements. Fortunately, he was able to demonstrate to their satisfaction that any other course would be disastrous for them and for the railroad.

By these draconian measures, taken swiftly, he was able to keep the intermodal yard functioning, complete the relocation of track and expansion of capacity, and later return to his erstwhile customers with the capability of improved service and a record of sound judgment in calling the shot correctly. His cancelled accounts returned, and he performed better than ever with his new facilities. He claims that the outstanding intermodal financial performance for the year was a result of holding the yard conversion downtime to a minimum so that he could run at greater capacity and efficiency later. Yes, he was promoted, but he had his superiors worried for a while.

Truck

A few years ago, a trucking executive accepted responsibility for corporate planning at the time the company was well launched on a program to become a transcontinental carrier. The planner had grave reservations about that strategy. He noted the trend toward deregulation and its probable unfavorable impact on trucking revenues, plus the difficulty in getting union wage rates reduced to match the freight rate reductions he expected. His proposed strategy was to sell off promptly many of the recently acquired companies and operating rights before their value declined dramatically. He recommended reinvestment in good regional, nonunion, trucking companies. These, he believed would have a better chance to cut costs as required. Specializing in regional service, they would avoid head-on competition with the majors and the need for heavy capital investment in the communications, computer equipment, and consolidation centers required for top efficiency in transcontinental service. The planner had a very tough selling job, but his recommendations were adopted. His judgment was vindicated during the next few years when the value of the properties the company had sold dropped sharply, while the new regional and nonunion operations continued to prosper, although they too suffered from the industry distress.

This is an impressive example of wise judgment. It is difficult to urge abandonment of a currently successful program and the adoption of a very different strategy. In such cases, the stakes are high, and for those who succeed, so are the rewards. In this illustration the planner is now the chief executive officer of the firm.

WHAT CAN WE DO?

By "we," I mean people like ourselves--educators, government officials, and business executives. We all have a stake in the development of the qualities of determination, imagination, and judgment in the next generation. Indeed, I believe that we will improve our own abilities by participating in this process.

No one has all of the answers. Therefore, I would like to make a few suggestions on what we can do. These ideas may be useful as examples, or as triggers to fire still better ideas in your minds, or those of your associates. Here are some examples of methods to enhance the development of determination, imagination, and judgment.

Determination

1. Arrange for speakers to discuss the role of determination and leadership in reaching objectives. A question period would be desirable to get further views

and discussion. Speakers could be invited to class, or to a business or government office, or to a seminar.

2. Review biographies and history for incidents in which individual determination was a critical factor in reaching goals. In terms of transportation, situations can be identified from ancient times, through the era of sailing ships, the covered wagon, the railroads, to the development of space. Summarize examples. Circulate the summaries, or arrange for discussions. Ask for suggestions on other examples. Ask for estimates of the importance of the contributions noted, or how their significance should be evaluated. The immediate objective is to get people to think about the significance of determination in effecting change, carrying out a successful project, and so forth.

3. Use problem cases (where some tough decisions must be made) in classes or executive seminars to make the problem analysis real and the role of determination clear to the participants. The problem case, with its setting and the active role of the student or executive in reaching a decision, focuses attention and provides an emotional involvement with the problem. These factors make it more likely that the lessons of the case discussion will become a part of the participant's pattern of thinking and his or her attitude to problems.

Imagination

1. Focus on the rate of change by using materials for reading and discussion that include a description of current developments and a discussion of their potential effects. Try to get people involved in the analysis and forecasting. A good example is to ask persons to prepare a graph on the rate of change in some aspect of development. Place time on the horizontal axis and a measure of the development being considered on the vertical axis. An upward sweeping curve will likely appear, showing not just change, but an increasing rate of change.

Transportation is a spectacular illustration of this. Let me give a few details, based on the speed with which man can travel. Through all recorded history, man could travel no faster than a good horse could carry him--until about 1830. Thus, our graph would show a horizontal line for top speed of about 35 to 40 mph extending as far back into history as you choose. In 1830 a locomotive named The Best Friend of Charleston went into scheduled service and provided a new standard of perhaps 50 mph. In 1898 the Empire State Express engine 999, with a train of four passenger cars, set a record of about 112 mph. When Lindberg flew across the Atlantic in 1927, one newspaper reported that he reached 150 mph. That speed was more than doubled in 1949 by the Lockheed Constellation (model L-649) with a speed of 350 mph. Ten years later, the Boeing 707 was flying at 550 mph. By 1975 the British Concord was flying to the United States with passengers at 1,350 mph, and military jets far exceeded that speed. Now astronauts circle the globe at speeds well above 25,000 mph. The rate of change in the last 150 years (since we broke the Oat Barrier) has been impressive in terms of speed and also in many other aspects of modern civilization.

Grandfather's experience is now almost useless in many circumstances, and much of our own is already outdated. We must emphasize change and the problems and methods of living with change, if future generations are to be both comfortable and efficient. I believe that we should place more emphasis on development of imagination in order to ensure that we, and especially those who follow after us, are oriented to live and work effectively with the increasing rate of change.

2. Obtain information on the Commercial Development of Space project for discussion and for development of imagination. There is now emphasis by the federal government on commercial development of space, and the various NASA centers are actively involved. A great deal of material and support is available. These materials can provide the basis for excellent exercises in analysis and in the application of imagination to new opportunities. The possible subjects include choices of plans, equipment selection, and project priorities for various space activities and facilities. Imagination can be stimulated by considering the possible applications and the potential benefits and problems involved in the many different commercial development of space ventures being considered.

3. Develop problem cases based on current innovations. These materials would provide readers and discussants a simulation of experience in anticipating possible results and in suggesting various recommendations. Here again, there appears to be a potential for further development of imagination in connection with current and near-future situations. Examples would include: applying the French TGV (high speed) train to certain routes in the United States, assessing the potential opportunities and problems of triple-trailers on U.S. highways, planning for substantial crew reductions on American ships, reviewing the prospects for fully automated subway trains.

4. Use problem situations with no standard solution for analysis and discussion. These situations can be taken from many fields of endeavor. Although they might be presented in the form of problem cases, that format is not required. An example follows. Published materials can be useful for development of team recommendations for the movement of natural gas from the North Slope of Alaska (Prudhoe Bay area) to commercial markets in North America and Europe. Some major options include (a) a pipeline for natural gas from the North Slope, parallel to the present oil pipeline; (b) use of ice-breaking tankers to carry liquified natural gas (at least two organizations have proposed designs); (c) construction of huge submarine tankers--nuclear-powered or natural-gas powered--that would load underwater, as proposed by the General Dynamics Corporation; and (d) airplanes, such as the 12-engine Large Resource Transport airplane (four times the gross weight of a B-747) proposed by the Boeing Company. Evaluations of the various transport systems can be in terms of the various types of problems involved. The prospects for a suitable solution to these problems can be rated "good", "fair", or "poor" because the information available and the technical expertise of the study group are not likely to permit greater distinctions.

This type of project appears to have great potential for stimulating constructive use of imagination in problem solving. Continued practice may also increase the imaginative capacity of the participants.

Judgment

Of the personal attributes I have chosen to discuss, this one is probably the most difficult on which to offer suggestions for training and development. Although most people would agree that judgment is developed by experience, there remains the question "What kind of experience is most useful?" We all remember the old saying that "there is a big difference between twenty years experience and one year's experience twenty times." The comment appears to have substantial merit, so let us determine what might be done to provide new and useful experiences that may be valuable in developing judgment.

1. Practice in evaluation of choices. This can be done with either problem cases or with less structured research projects. For example, the research project on transportation of natural gas from Alaska would be carried a bit further. Having identified the elements to be evaluated (judgment), consider their relative importance (judgment) and estimate their feasibility in terms of problems to be resolved (judgment). From these considerations, a priority ranking or overall rating of the options (judgment) for actual use can be derived.

Some problem cases that represent practice in analysis and development of judgment are: gas turbine versus diesel locomotives, analysis of poor truck terminal performance, evaluation of high-speed monorail service between the San Francisco Airport and the city center, choosing between roll-on/roll-off ships and large tug barge roll-on/roll-off combinations for particular routes. Many good cases are available. The question is really which cases will provide the greatest stimulation and advantage for the person or group involved.

2. Work experience in creating a plan. I believe that when persons are actively involved in developing a plan, the intellectual and emotional aspects of making the various decisions substantially enhances the development of judgment. Here is an example.

Professor Peter Banks of the Stanford School of Engineering has been running a two-quarter class each year in which the students (30 or more) design and plan for the use of a new device. This year the new device was a remote sensing satellite for agriculture. Naturally it was called AGSAT. The satellite appears to be distinctly superior to anything now available, thus serious consideration is being given to establishing a business and producing and marketing the product. The student teams had to analyze, design, coordinate, and make judgments on myraid matters in developing the plans for the satellite. The details are being published in a book that will be about 400 printed pages; so it is obvious that there was plenty of room for decision making in determining the concepts, capacities, trade-offs, and design features of the satellite, plus its launching and communications systems.

3. Guest speakers on analysis of tough decisions. Business and government organizations, as well as colleges and universities, can easily use guest speakers to help those interested to improve their judgment and decision making. These events, including question periods, could be organized as luncheon meetings, after-work sessions, or as lectures to large groups. With large audiences, questions are often sent forward from the floor to the session chairman; the questions can then be sorted by frequency and importance and handed to the speaker(s) in some priority order for discussion after the prepared talk(s).

As an example with a small audience, the vice president and general counsel of Consolidated Freightways agreed to speak to a class at Stanford University about the decision to sue the state of Iowa to permit the use of tandem trailers in that state. The students had already read a problem case concerning the matter. The case put them in the position of an editorial writer for the Des Moines Register, the largest newspaper in Iowa, after the case had gone to the U.S. Supreme Court. Robert Stetson, the vice president and general counsel of Consolidated Freightways, described the various decisions that had to be made in connection with the case. He responded frankly to such questions as "Why did you pick Iowa?" "Why didn't any other company in the trucking industry support you?", "If you were doing it again, would you change your approach?", "What did you do about the general issue after winning the Iowa case, and why?". It was very instructive. Stetson developed tremendous interest with his frank comments. I am certain that his talk contributed more to the students' understanding of decision making, and to their personal skill, than could have been accomplished with a large number of cases lacking an "I was there" speaker.

CONCLUSION

I always find it encouraging to exchange ideas with friends in the business world, government, and academe. This process of exchange can be counted on to generate insight and to create new approaches. For maximum benefit, we need to shape our questions and comments carefully because they structure the responses we will obtain. For this reason, my coverage in this paper has been broad and at the same time specific. If the remarks I have made stimulate further ideas among you, my goal has been accomplished.

Training Requirements for Transportation Operations Personnel

James E. Reading, Barbara A. England, and James W. Strecker

Training Requirements for transit operations involve two important factors: skill requirements for hiring and training provided after a person is hired.

The human resources and personnel function of setting realistic, minimum qualifications and effective recruitment is crucial in determining the pretraining needed for a particular position. Even with competent candidates for the job, the process cannot stop here. It is unrealistic to expect a new employee to enter a job with all the detailed training from schools, universities, or from life itself without some specialized training and development. An organization must provide, in one form or another, the avenues to assure self-motivation and advancement for its employees. Various avenues available to organizations include outside courses; seminars and workshops offered by colleges, universities, professional organizations, manufacturers and vendors; and tuition reimbursement.

Human resources departments should be adept in job analysis and job evaluation. The job analysis and job evaluation process begins with the conscientious completion of extensive job questionnaires by employees. The questionnaires should be reviewed and verified by supervisors, department heads, and human resources department officers. From the questionnaires, a comprehensive job description is written and again verified and approved by the appropriate levels of management, including the general manager or chief executive officer.

In this paper the Operations Division, Central Ohio Transit Authority (COTA), is examined to illustrate the different types of training and development a transit authority might expect from and offer to its employees. It is difficult to make one direct statement as to general educational background for operations personnel because of the diverse range of functions within the division. For this reason each of the three major areas comprising COTA's Operations Division is examined separately.

For higher level managerial positions such as assistant general manager, operations executive assistant, and the superintendents of the different departments, a higher education in business administration is desired, along with training in the area of specialization. A combination of training and experience in labor relations, human relations and supervision, budget, and effective communications is highly desirable.

Operation divisions of transit authorities the size and scope of COTA are usually divided into three major functional areas: transportation, maintenance, and buildings and grounds. At COTA, the operations division comprises 87 percent of the authority's employees, including all who are represented by the Transport Workers Union (see Figure 1).

The transportation department is the largest in the operations division; it has 448 motor coach operators, in addition to transportation managers and super-

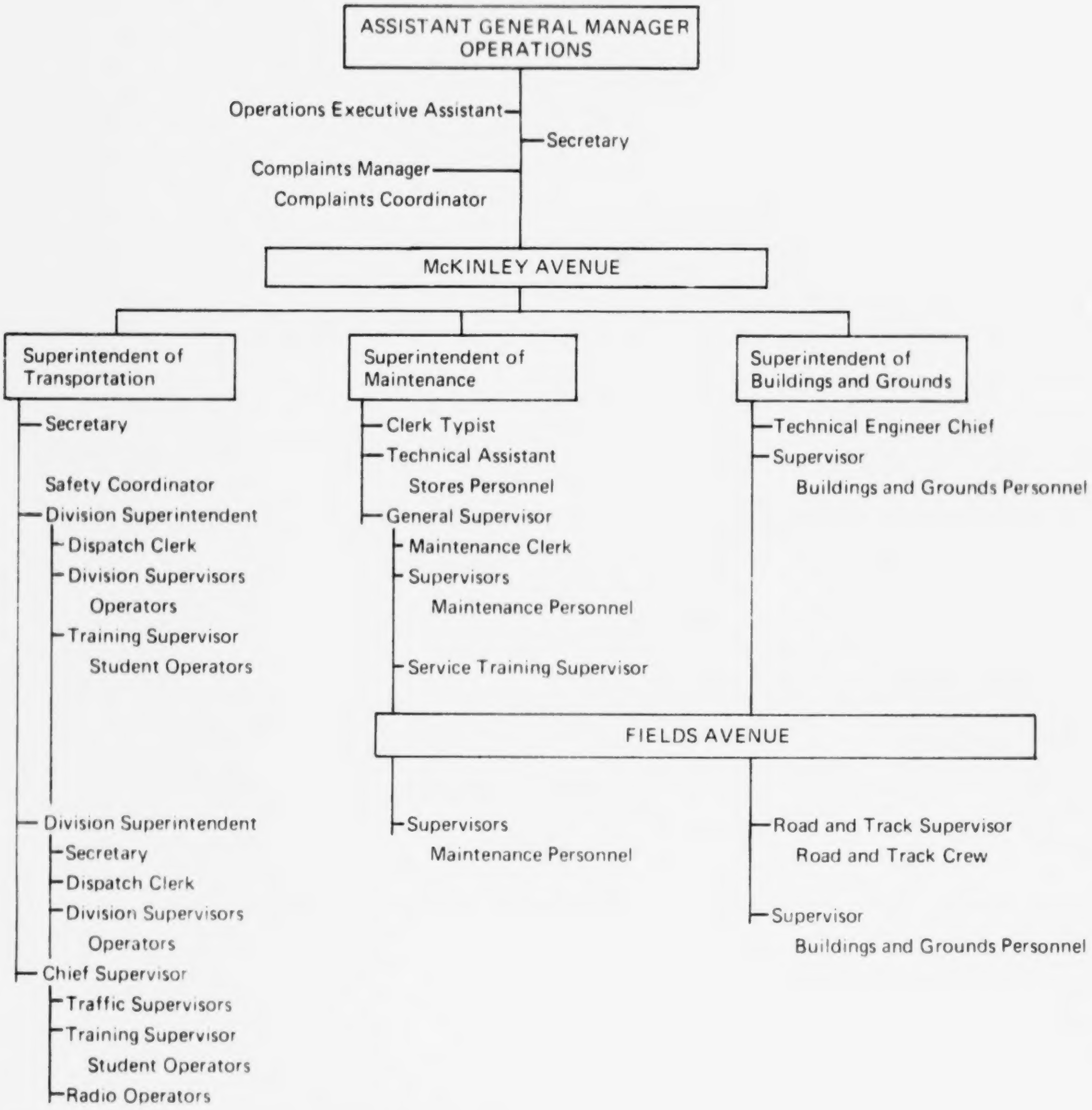
ASSISTANT GENERAL MANAGER OPERATIONS
Operations Executive Assistant
Secretary
Complaints Manager
Complaints Coordinator
McKINLEY AVENUE
Superintendent of Transportation
Secretary
Safety Coordinator
Division Superintendent
Dispatch Clerk
Division Supervisors
Operators
Training Supervisor
Student Operators
Division Superintendent
Secretary
Dispatch Clerk
Division Supervisors
Operators
Chief Supervisor
Traffic Supervisors
Training Supervisor
Student Operators
Radio Operators
Superintendent of Maintenance
Clerk Typist
Technical Assistant
Stores Personnel
General Supervisor
Maintenance Clerk
Supervisors
Maintenance Personnel
Service Training Supervisor
Supervisors
Maintenance Personnel
Superintendent of Buildings and Grounds
Technical Engineer Chief
Supervisor
Buildings and Grounds Personnel
FIELDS AVENUE
Road and Track Supervisor
Road and Track Crew
Supervisor
Buildings and Grounds Personnel

FIGURE 1 COTA operations division.

visors, and clerical staff. The maintenance department is composed of 100 unionized employees (heavy equipment, service line, inspection, and running repair), maintenance managers and supervisors, and clerical staff. Buildings and grounds is the smallest department in number with 30 unionized employees (building maintenance, utility, unskilled labor, and janitors); buildings and grounds superintendent; supervisors; and clerical staff.

TRANSPORTATION DEPARTMENT

The following qualifications for motor coach operator are necessary for employment:

1. At least 25 years old,
2. No relatives employed by COTA,
3. No previous employment by COTA or its predecessor,
4. Have own transportation,
5. Valid Ohio driver's license,
6. No moving traffic violations in last 2 years,
7. No more than two moving traffic violations in last 5 years,
8. No history of moving violations,
9. Four years employment in last 5 years (with excellent references), and
10. No physical disabilities to prohibit or limit ability to perform job.

Once candidates have been selected as motor coach operators, they begin an intensive training program as student operators for 6 to 7 weeks. The COTA Transportation Department has two training supervisors who instruct students using a training package developed by the AFL-CIO Appalachian Council. The training package includes film strips, films, and detailed explanations of bus maneuvers, defensive driving, and passenger relations.

Also, COTA's policies and bulletins are covered extensively twice during the training period. New student operators work with the training supervisors for 9 days of classroom time and actual bus-driving experience. The students are then sent on the road with selected operators to learn specific routes and to practice driving. Finally, they must take a test on the various routes to qualify as motor coach operators. At this time, the students receive an operator's handbook, the bargaining agreement between COTA and Transport Workers Local 208, and a bus manual from the Flxible Corporation.

The two training supervisors also conduct refresher training for motor coach operators involved in preventable accidents or operators who have been absent due to lengthy illnesses. Once a year, all motor coach operators are required to attend a refresher training seminar on defensive driving. During the refresher training, reoccurring driving problems that appear to apply to all drivers are discussed in detail.

All drivers are trained on use of the automated fareboxes. This training is a cooperative venture between the transportation and finance departments. A video training tape is used for continual viewing in the operators' lounges. A transportation training supervisor is available for additional explanation when needed.

Future training is being developed for motor coach operators and radio room operators (supervisors) in the implementation and operation of a computerized two-way radio system. The contractor will be involved in the initial training, and staff will be prepared to orient and train all future users of the radio system.

MAINTENANCE DEPARTMENT

Because the entry-level position and many other positions in the maintenance department require the operation of a motor coach, new maintenance employees are given 8 hr of driving instruction by the transportation training supervisors. Then, entry-level staff are trained by a maintenance supervisor in the job requirements of the position that involves cleaning the coach.

From this position, maintenance employees usually advance to the service line where a maintenance supervisor is responsible for much of the on-the-job training. Employees enter classified positions and receive approximately 170 hr of training from a combination of maintenance supervisors and other employees in the area into which they bid. Figure 2 shows the various functional areas and the progression employees can make.

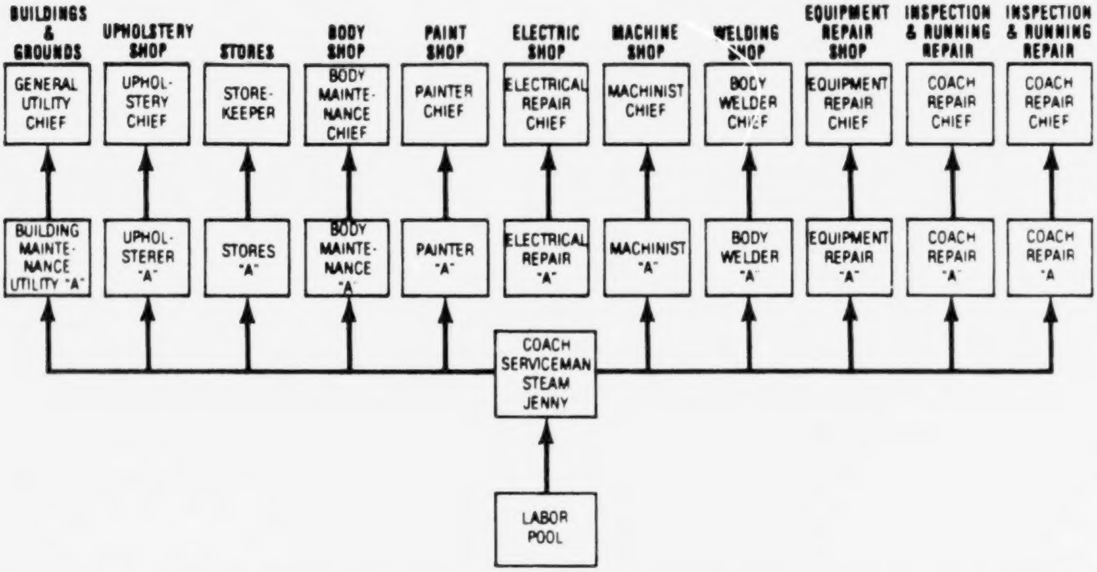
BUILDINGS & GROUNDS
UPHOLSTERY SHOP
STORES
BODY SHOP
PAINT SHOP
ELECTRIC SHOP
MACHINE SHOP
WELDING SHOP
EQUIPMENT REPAIR SHOP
INSPECTION & RUNNING REPAIR
INSPECTION & RUNNING REPAIR
GENERAL UTILITY CHIEF
UPHOLSTERY CHIEF
STOREKEEPER
BODY MAINTENANCE CHIEF
PAINTER CHIEF
ELECTRICAL REPAIR CHIEF
MACHINIST CHIEF
BODY WELDER CHIEF
EQUIPMENT REPAIR CHIEF
COACH REPAIR CHIEF
COACH REPAIR CHIEF
BUILDING MAINTENANCE UTILITY "A"
UPHOLSTERER "A"
STORES "A"
BODY MAINTENANCE "A"
PAINTER "A"
ELECTRICAL REPAIR "A"
MACHINIST "A"
BODY WELDER "A"
EQUIPMENT REPAIR "A"
COACH REPAIR "A"
COACH REPAIR "A
COACH SERVICEMAN STEAM JENNY
LABOR POOL

FIGURE 2 COTA service department's progression chart. [Note: This is only a line of progression chart and does not represent vacancies.]

The maintenance department takes advantage of training seminars offered by various manufacturers. For example, employees are sent to Great Lakes for basic diesel mechanics, Allison of Indianapolis for transmission work, and Flxible Corporation for body work. All coach electricians are sent to a 1-week school at Delco Remy of Anderson, Indiana, which includes training in coach air-conditioning repair. Recently, five employees and two supervisors were sent to Chicago for instruction in repairing the new automated fareboxes.

Often manufacturers are invited to the facilities to present workshops on their products and to discuss proper repair procedures. Other manufacturers send video tape demonstrations that can be viewed by one or several employees as required. For example, Midland Ross has a video tape for brake repair. Increasingly, COTA is requiring this type of service in purchase contracts because it has proven to be an effective means of training.

One COTA electrician was selected to participate in the development of a detailed job-performance manual on coach electrical repair in conjunction with the AFL-CIO Appalachian Regional Council program. COTA's recognition of the importance of on-the-job training led to participation in this effort.

BUILDINGS AND GROUNDS DEPARTMENT

This department uses contractors and manufacturers of new equipment to train their employees. The pump and seal school is one example. Also, the chiefs in buildings and grounds serve as instructors for new employees as do other employees acquainted with a specific job or piece of equipment. New employees are rotated throughout the different areas within the department to orient and train them in all department functions.

Supervisors attend seminars in custodial training and preventive maintenance. In the future, it is hoped that employees can be sent to trade schools for specific training. In addition, management is preparing a training manual and detailed work cards on the various jobs and schedules for maintenance of building equipment, passenger shelters, and park and ride sites. Most electrical work, other than heating and ventilating, is done by outside contractors.

Training in industrial safety is another area in which a transit authority should be concerned. At COTA, regular safety sessions are presented by the industrial safety coordinator. These training sessions are held in employee lounges for the convenience of maintenance and buildings and grounds personnel. Films and informational handouts are made available on such topics as fire prevention, slip and fall protection, safety apparel, and safety manuals. Safety bulletin boards are used extensively. In addition, the industrial safety coordinator counsels individuals on safety issues on the job.

COTA has recently expanded its commitment to internal training and development by creating a new training and development coordinator position within the human resources department. But even before the creation of this position, COTA actively sought training opportunities for all employees and encouraged educational development through the tuition reimbursement program. Outside training seminars and pertinent courses are brought to the attention of supervisors and employees to encourage employees to continually develop in their current jobs or to work to qualify for promotional opportunities.

A transit authority should require a certain level of training and experience before employees take positions, but should follow up on this basic experience with training and development after employees are on the job. Employees in new positions should be enrolled in specialized programs to enhance their ability to perform their new responsibilities. Many examples can be cited in COTA's experience.

The human resources director was sent to the Wharton School to study human resources development. This same person continued self-development by taking advantage of COTA's tuition reimbursement program in labor relations and recently has been promoted to assistant general manager of operations.

At least 15 middle managers and supervisors have been sent to the management programs at Northeastern University of Tennessee, Indiana University's Institute for Transit Management, the University of Wisconsin, and the University of Northern Florida.

As a result of this positive stance in providing ongoing training opportunities, many employees have been able to grow, assume more responsible positions, and enhance COTA's position within the transit community. COTA fosters and supports the concept of promotion from within the company and encourages all qualified employees to apply for higher positions within the Authority. All employees are hired because they are capable of performing the specific job in question and indicate some potential, in many cases, of advancing to higher level positions. Those employees who participate in training programs position themselves for upward mobility.

COTA's promotions and transfers policy provides for mobility within the COTA structure, assuring employees the opportunity to improve their rate of pay, conditions of employment, and job satisfaction by establishing a procedure for applying for advancement. Job vacancies are posted in conspicuous, specified locations for 5 consecutive working days before the position is closed to in-house applicants. For 3 days immediately following the fifth day of posting, no outside applications for a posted job may be accepted.

Criteria used to evaluate candidates include their work record, education and training (including COTA's effective communications course), skills knowledge related specifically to the job, and results of a supervisory-managerial test of general aptitude and attitudes about people and supervision.

COTA believes in upward mobility for qualified employees. A female employee was hired in 1977 as a mail clerk at an annual salary of $5,609. A short time later, she was promoted to the newly created clerk-typist position in the accident investigation section. She was quickly promoted to accounting clerk. After slightly more than 1 year of competent performance as an accounting clerk, she was promoted to finance secretary. In 1981 after about 3 years as finance secretary, she was promoted to finance coordinator at an annual salary of $25,480. In 16 years a black male progressed from student motor coach operator to traffic supervisor and, in 1984, to division superintendent, supervising 448 operators. Another black male was hired as a purchasing clerk; he advanced to minority business enterprise (MBE) secretary, then to administrative assistant to the board of trustees, and is now COTA's MBE officer. One female employee moved up from receptionist to the general manager's executive secretary to administrative assistant and, finally, to scheduling specialist in a span of 5 years. In total, 26 minority and female employees have been promoted from within the organization within the past 5 years.

Training programs are continually being developed and implemented to assist supervisors in dealing with bicultural groups. Quarterly and annual progress reports are provided to top management. Recommendations are made, not only to enhance the company's affirmative action program, but to improve the quality of work life for all employees.

COTA management is continually encouraging employees to participate in educational programs and specialized training to enhance job performance and to provide promotion opportunities. Additionally, employees are paid for the amount of time spent in educational sessions required by COTA in accordance with the union agreement or salary administration plan, or both. COTA reimburses the tuition paid by employees for educational programs related to some phase of COTA operation, and all employees are encouraged to attend local and national seminars in their areas of concentration; COTA pays the cost.

The ability to communicate and effectively deal with people, especially in supervisory positions, is one of the most important areas COTA has addressed. COTA contracted with a local university to provide an 8-week supervisory training program for employees. The training is for those new to supervision and employees interested in general development or future supervisory possibilities. In order to tailor this course to the needs of transit and COTA personnel, two employees from the human resources department attended a 2-week seminar in Chicago created by Consult Limited and sponsored by the Urban Mass Transportation Administration (UMTA).

After staff returned to COTA, the course was adapted to COTA's time frame and requirements. To date, COTA has offered the new 16-hr course twice and has received outstanding ratings by employees who attended. Some of the topics in this course are active listening skills, human behavior, discipline and conflict, identifying the troubled employee, and group dynamics. An interesting thing happened at the completion of the first program. Participants suggested the program name be changed from Supervisory Training to Effective Communications and Leadership in order not to discourage attendance by those not specifically interested in supervision.

Other in-house training programs are in stress management and weight management. These seminars last 2 to 3 hr with 12 to 15 interested employees. In stress training, participants are encouraged to identify the causes and symptoms of stress, discuss alternatives for dealing with stress, and are trained in deep muscle relaxation.

COTA has also instituted quality of work life programs. A quality circles team has been set up in the telephone information center, and representative employees in transportation and maintenance have established communication and problem-solving committees. Both of these programs involve training in problem solving, team work, and data collection. Suggestions from the information center's quality circle resulted in certain specialized training and the development of a detailed training and refresher training manual for that unit.

By establishing realistic educational background and experience for new employees and offering varied avenues of training and development to employees after employment, transit authorities receive many benefits: higher morale, less turnover, better overall attendance, fewer incidents of tardiness, fewer grievances, and more qualified applicants and employees.

The development process is ongoing and, oftentimes, overall benefits cannot be assessed for a number of years. The success of such a process and the continuation of transit depends on the realistic assessment of skills needed in operations and the establishment of a comprehensive program to provide employees with technical skills, the ability to deal effectively with people and problems, and the leadership qualities to carry transit into the next century.

Supplying Transportation Education

SUMMARY OF PAPERS

Lester A. Hoel

Today my task is to summarize six papers on the topic "Demand for Transportation Education." Each paper is summarized separately. The authors and their topics are as follows:

- Transportation Education--University Degree Programs, Edward Biemborn
- Transportation Education: Technical Training and Continuing Education, David Cyra
- Efficient Utilization of Transportation Research and Educational Resources, William E. Spreitzer
- Transportation Research and Its Link to Education, Robert E. Paaswell
- Education and Training Needs of Women in Transportation, Lillian C. Liburdi
- Transportation Careers for Minorities, Katie Dorsett and Julian Benjamin

TRANSPORTATION EDUCATION: UNIVERSITY DEGREE PROGRAMS

Beimborn begins by stating that transportation education today can be characterized in four ways: (a) most programs are small and diverse, (b) they follow a centered approach, (c) research is the main educational technique, and (d) they function similar to a deregulated industry. There are probably no more than 25 U.S. schools with an active program, presumably graduate, although some undergraduate, in transportation and only a handful with more than five full-time faculty in transportation. The total Ph.D. output in transportation in the United States, according to Beimborn, is usually less than 10 per year. Transportation programs are also diverse; some schools have programs in traffic, planning, highway design, materials, policy analysis, and safety.

Transportation is an oddity at most universities, because it does not fit neatly into an established organization. Many schools have, therefore, created transportation centers that usually restrict their activity to research, whereas the academic programs remain in traditional departments. Centers vary in size from those with staffs of 10 or more and research budgets in the millions to simply paper organizations. Research is a tool used to educate both students and faculty in transportation. Education and research are synonymous.

Beimborn compares transportation programs to recently deregulated industries, such as airlines. There are a group of schools that have been in existence for a long time and are similar to the established carriers. A second group is similar to new entrants; some enter the market and remain, whereas others leave after a period of time.

Beimborn speculates that the newer programs are more innovative, whereas the older ones are perhaps more set in their ways.

The three major problems facing university transportation programs today are the job market, level of support, and the capability to maintain relevancy. The wide fluctuations in the job market make it difficult to run a program because there is not the continuity of demand that ensures a steady influx of students. Low salaries, compared with other professional fields, also discourage young people from entering this field. Outside support for faculty research is also uncertain.

Many transportation research programs are out of touch with the users of their product and have lost their capability to do research that is useful to the transportation industry. Beimborn believes that we need to return to the time when education and practice were closer to each other, and that we must work harder to ensure that our results are relevant and useful.

Future directions for university transportation programs include development of closer contacts with users of university research, special emphasis on continuing education, establishment of a more rational funding base, and greater emphasis on innovation and creativity.

Beimborn states that we need to revitalize our universities as the sources of new ideas and approaches to dealing with transportation problems. Our current students will spend most of their working lives in the 21st century, and we must prepare them to deal with the challenges of the future.

TRANSPORTATION EDUCATION: TECHNICAL TRAINING AND CONTINUING EDUCATION

Cyra states that continuing education and technical training are used interchangeably to refer to professional education that meets the demands of the workplace and provides skill enrichment. He notes that continuing education will be more important and relevant as the need to maintain knowledge and skills during a person's career continues.

Continuing education processes involve six elements: (a) inquiry, (b) needs assessment, (c) program development, (d) instruction, (e) work-site performance, and (f) training evaluation. Continuing education is a collaborative effort among skill builders, students, employers, and educators. There are three learning situations available and each should be included in the educational process. These are the inquiry mode, which is used where outcomes are uncertain and new ideas or procedures are being worked out; the instruction mode, which is the traditional teaching situation, dissemination of skills or knowledge with structured participation from students; and the performance mode, which occurs after the inquiry and instruction modes are applied in professional activity.

There are seven principles of adult learning that are helpful in understanding the continuing education process. Learners must want to learn. The learning environment should be comfortable. There should be mutual respect between students and instructors, and students should feel free to express themselves, to disagree, to supplement with their own experiences, ideas, and opinions. Students should perceive the goals of the learning experience as consistent with their own objectives. Program planning should involve input from the potential market in order that this input and interest be guaranteed, and the learner should actively participate in the learning process, which should make use of the experience of the learners. Finally, goals should be defined, and the learner should have a sense of progress that these goals are being achieved.

According to Cyra, continuing education in transportation is facing the challenge "to be a consummation devoutly to be wished, rather than a burden to be borne." Transportation practitioners are not clamoring for continuing education, perhaps, because of a genuine lack of interest or a failure of the academic community to address their needs. The following actions could alter this condition. Transportation professional associations should be encouraged to take increased responsibility for fostering a zest for learning among their members. Professional attitudes of pride should be encouraged among all workers. Relevance of programs should be made clear, especially those that teach nontechnical skills not traditionally associated with the job.

A systems approach should be used in structuring continuing education in transportation, and the three modes of learning should be taken into account when planning continuing education programs. Transportation professional associations should collaborate with employers and government agencies in planning and providing training. Principles of adult learning should be incorporated into program development. Lectures are not sufficient but must be supplemented with opinions and experiences of the learner that reflect confidence and trust between the teacher and the student. A continuing education professional is in the information technology transfer business and, as such, must have the ability to communicate and relate comfortably with different kinds of people.

Finally, continuing education is the responsibility of each member of the transportation community. Identification of needs and then implementation of a program must come from a natural collaboration of all segments of the transportation community.

EFFICIENT UTILIZATION OF TRANSPORTATION RESEARCH AND EDUCATIONAL RESOURCES

Spreitzer notes that transportation educators, researchers, and practitioners are concerned about the level of support for transportation. The pendulum will swing, he notes, if experience is a guide, and improved funding and the demand for trained professionals will return. In the interim, the challenge is to make creative and effective use of existing resources.

Several premises underlie this paper: the demand for trained personnel should lead the supply; fundamental conflicts exist between research objectives and applied opportunities, especially in universities; the responsibility for major support of basic research remains with the federal government; and the research community consists of high-, medium-, and low-quality personnel. The highly skilled will always have support. The least capable should be weeded out, and those in the middle face the greatest funding challenge.

Finally, Spreitzer states that griping and commiserating about the current lack of funds is simply counterproductive. Universities should become involved in consulting or contract work during times of financial shortages and declining markets for long-range research because contacts made will build exposure and credibility and could result in opportunities for basic research. Spreitzer notes that timely topics have generated financial support for research; for example, the Strategic Transportation Research Study initiated by TRB is certainly in that category.

Bootstrapping is another way to get started, and it could come from seed money grants, building block support from other contracts, or entering into new areas through professional and technical societies. Research with industry can be exciting and stimulating as theories are tested in a real world environment. Consulting for state and local sponsors in established areas can lead to support for newly developing topics.

Finally, Spreitzer summarizes by stating that the present paucity of funding for transportation research is natural, temporary, and probably deserved. The elimination of less capable investigators from the transportation research field is healthy. The challenge is for deserving investigators to do what is necessary to justify the importance and value of their proposed work.

TRANSPORTATION RESEARCH AND ITS LINK TO EDUCATION

This paper deals with that aspect of transportation research that is conducted at universities and colleges. It covers the objectives, conduct of research in an academic setting, research needs and support, and the future of university research.

The objectives of transportation research and the conduct of research in an academic setting are described thoroughly. Emphasis is placed on the types of organizations that conduct research; the role of universities in conducting theoretical and applied research; the academic setting for research, which is continuity, range of disciplines, and the utilization of students; and the measures used by universities to evaluate the research product of its faculty.

Within universities, research is conducted in many ways but always with a unique product--a master's thesis or a doctoral dissertation. This is a training function that teaches the student the rigors of research, focuses him or her on a problem in immaculate detail, helps the student to develop expertise in an area, and assists the student to become a fledgling professional by making a contribution to the field through a written treatise.

Paaswell offers the following conclusions: Transportation research is an integral part of academic programs at universities and colleges. It is normally conducted by a team that consists of at least one faculty and one student, often more of both and often interdisciplinary.

Transportation research has a beneficial impact on academic programs. It provides new ideas and theories for use in formal curriculum and training for both graduate and undergraduate students in the demands of their future profession and in the methods of conducting rigorous inquiry.

Transportation research today is shifting from dealing with problems concerning the building and development of our infrastructure to problems of managing, operating, and extending its life.

Transportation research at universities should be dealing with longer term needs of the population, including the impacts of rapidly changing demographics, a shifting economy, and the growing role of computers and communication in the workplace. Academic transportation research has been influenced by short-run pragmatically stated national, state, and local needs. Academic transportation research has been responsive, and there are many examples of its contribution.

Academic research responds to its own reward structure. Promotion and tenure are often based on the quality and quantity of publications and the ability to obtain sponsored research. In recent years, the pressure to obtain sponsored research per se has begun to outweigh the academic merit of much of the research. What is lacking at traditionally strong transportation institutions is the development of new research programs and research agendas that will address longer term, innovative transportation agendas.

The problem of developing such programs comes not from a lack of interest by faculty and students, but from a lack of encouragement by the institutions themselves. Transportation research must again capture the uniqueness of inquiry that academic institutions can provide.

EDUCATION AND TRAINING NEEDS OF WOMEN IN TRANSPORTATION

The focus of this paper is whether women, as participants in the transportation industry, are achieving success comparable to male practitioners who work in this field and whether female industry practitioners have educational and training needs that differ from their male counterparts. Also, the question is raised: How many female practitioners are there and what steps should be taken to assure the attractiveness of transportation as a career for women?

The author offers the premise that the transportation industry, with its competitive pressures, must capitalize on all its resources, the most critical of which is human capital.

No major effort has been initiated to assess the skills that contribute to a successful transportation career or when technical versus managerial competence is critical to success. Also, there have been no analyses of successful male transportation managers' backgrounds that could be useful for role model and career planning purposes.

In 1970, 18 percent of the nation's workforce consisted of women in full-time positions and 11 percent in part-time positions. In 1980, 35 percent of the workforce consisted of women in full-time positions and 12 percent in part-time positions. By 1984 women comprised 45 percent of all workers.

Women surveyed by an American Public Transportation Association Task Force cited real or perceived barriers to career mobility because of their sex, stereotypical ideas and moods, negative attitudes toward women in top management positions, inability to relocate, and educational disparities. Women cited being confined to nonoperational administrative positions in personnel, marketing, and community service, which perpetuate the status quo. Women employed in transit desire more exposure to all facets of the industry, and they place great emphasis on availability of educational and career development programs.

Training courses were not listed as a significant factor in the background of these women, although 82 percent had taken training courses during their career. Experience and personal contacts were ranked highly.

Women questioned the need for academic training in transportation and whether the degree relates to job performance and success or whether the requirement is a means to discriminate. Other concerns were whether degree holders possess basic job skills, industry-specific skills, or functional skills. At the entry level, it was believed that an employer looks for basic job skills and evidence that the individual will prosper and that the industry skills and history and culture of the business are learned on the job.

Knowledge is important to success in a transportation career, but many women believed that they have been denied or deprived of opportunities to learn on the job.

Many women believed that, even with the requisite training and education, skill level and ability, they were frequently not offered the opportunity to compete because of job qualification requirements or their lack of stature in the organization.

If we value our human capital, we should examine why women appear not to be achieving success comparable to their male counterparts. Initiatives suggested are an examination of the education and career paths of transportation and non-transportation industry executives to determine factors of success. What specific educational backgrounds are likely to lead to success? How many women are in various transportation industries and what positions do they hold? Why are women underrepresented in managerial roles in transportation? What are the barriers to career development for women?

Evaluate the support structure, including mentoring and role models. What are the opportunities for promotion and growth? And determine if there are differences in the process for men and women and, if so, why? These steps should be viewed as an investment in the future and an effort not to be taken lightly but one to achieve greater growth and stability for people and businesses.

TRANSPORTATION CAREERS FOR MINORITIES

Minorities have played a major role in the development of transportation systems, both as users and as employees. They drove the carriages during slavery, built and repaired the railroads, navigated ships, invented a self-lubrication device for train steam engines and the first traffic light, made the beds, and cooked and served meals on transportation carriers.

Opportunities have been primarily at the entry or low level of the career ladder, and opportunities for professionals have been limited in all modes. Participation of minorities in the transportation industry has been directly related to the civil rights movement. The results have been passage of laws and executive orders on nondiscrimination and the White House initiative on historically black colleges.

The time has come for minorities to seek their rightful place among professionals in the transportation industry, and they can and should occupy more of these positions. Approximately 72 percent of all managerial, administrative positions are held by white males, and only 3 percent are held by blacks. These figures are 20 percent higher for minorities than 10 years ago, but still show an underrepresentation in managerial positions. There is evidence that the situation is even more pronounced in the transportation industry.

There is good potential for graduates throughout the transportation industry but the greatest number of positions are in motor freight, and the higher salaries are in physical distribution management. This implies that academic programs for minorities must include carrier and physical distribution management. University programs provide training in three basic areas: transportation planning, career and physical distribution management, and transportation engineering.

The needs for professionals in each of these areas is changing, and these changes must be reflected in curriculum design. Historically black colleges enroll more than 60 percent of all black students. They provide points of access and offer better odds for retention and attainment for blacks than do other institutions.

Few historically black colleges have transportation programs. Three undergraduate degree programs in transportation exist at North Carolina A&T University, Virginia State College, and Florida Memorial College. Three have master's programs in transportation: North Carolina A&T, Morgan State, and Texas Southern Universities. Academic programs at minority campuses tend to overemphasize public sector training; however, graduates who accepted positions in freight transportation were given starting salaries twice that of graduates in the public sector.

Because programs that assume advanced mathematical skills, such as engineering, will necessarily exclude the majority of students with average math skills and because business programs require competency in a wide range of skills, not to mention the marketability of their graduates, it is suggested that transportation programs for minorities be located in a school of business and emphasize carrier and physical distribution management.

The other approach is a multidisciplinary one followed by many universities; for example, Morgan State University has adopted this approach. These two strategies for preparing minority transportation professionals have advantages and disadvantages that parallel the strategies at nonminority colleges. A business curriculum requires more business-oriented prerequisites and has the advantage of greater strength in administration and in the transportation management market.

The multidisciplinary approach provides transportation courses from the outset and will attract an interdisciplinary student body. Only time will tell, according to the authors, which approach provides the better option for minorities who want to pursue careers as transportation professionals.

The role of historically black colleges is to train minorities for these positions, but this has been limited to a handful of programs. Although these programs are geared to careers in urban transportation, there should be an effort to focus on freight transportation where salaries are higher and opportunities are better. More programs are needed in these areas at minority institutions and more minorities need to be recruited at institutions with established transportation programs.

Transportation Education: University Degree Programs

Edward Beimborn

I would like to present an overview of university degree programs in transportation education. Basically this is a state-of-the-art report of the current status of transportation education. I will also discuss the problems we face and present some ideas for future directions.

STATUS OF TRANSPORTATION EDUCATION

The first topic I would like to address is the current status of transportation education in universities. Transportation programs can generally be viewed as small and diverse, and research is used as a major educational technique through a centered approach. In many ways it has characteristics similar to a deregulated industry. These terms are explained in the following sections.

Small and Diverse

Transportation programs in universities are generally quite small in comparison to other university programs and are considerably diverse. There probably are no more than 25 schools that have an active transportation program, and only a handful of schools that have more than five full-time faculty in transportation. The total Ph.D. output in transportation in the United States is usually less than 10 per year (depending on how transportation is defined). Most of the faculty in transportation in this country know each other. This is possible simply because there are so few.

The programs in transportation are also diverse, perhaps because they are so small. Transportation education occurs primarily under the wing of civil engineering, especially as it relates to planning, design, and control. It appears to be accepted that there must be at least one transportation faculty member in order to have a legitimate civil engineering department. Business schools sometimes develop a specialization in transportation management aimed at the freight industry and the private sector with concentrations in logistics or physical distribution. It does not appear to be an essential part of a business school in that many business schools appear to do well without any transport emphasis. Transportation specialists can also be found in geography, economics, urban affairs, architecture, and urban planning, and perhaps agriculture. There are very few degree programs in transportation as such. Nearly all who study transportation do so under one of the preceding departments.

Transportation programs are also diverse in the problem areas they examine.

Some schools work extensively in traffic, others work in planning, highway design, materials, policy analysis, or safety. Few schools are of sufficient size to be strong in several of these areas.

Centered Approach

A university can be described as a collection of schools, colleges, and departments connected together by a heating plant. Transportation studies in universities are quite similar to heating plants in that they attempt to connect different parts of a university. Transportation education in universities almost always appears to follow a centered approach. Transportation still is an oddity at most universities in that it does not neatly fit into the established organization. We all understand the interdisciplinary approach, and it has been the norm in transportation education during the last 20 years. But it is still hard to manage such an approach within the traditional university structure. Many schools have established transportation centers in which faculty and students who have an interest in transportation can work together in an interdisciplinary manner. Centers almost always restrict their activity to research or projects, whereas control of courses and academic programs remains with traditional departments.

Transportation centers vary considerably in size and scope. On one extreme, there are centers that have full-time staffs of 10 or more people and handle several million dollars worth of work per year. On the other extreme, there are paper organizations that consist of a drawer of letterhead and little else. Centers can be a useful mechanism to focus activity in transportation, to provide visibility, and to help develop solid programs for transportation research and education.

Universities are unique in that they have tremendous resources and capabilities across a wide variety of disciplines. When these resources can be effectively brought together in an atmosphere of free inquiry, the results can be outstanding. Not only can new insights and knowledge be developed, but in the process, students are educated and prepared to use that knowledge for years to come. Ideally a center provides a mechanism to do this. In some cases it works very well. Other times it is a disaster where rivalries, jealousy, and conflict are the main activities that take place. University faculty and staff generally affiliated with a center need a high degree of tolerance by all to sustain an effective center. More than one school has experienced internal division that has destroyed the value of its center. The use of a centered approach means that transportation work in a university can be quite precarious. Many programs rest on one or two key individuals and on mutual trust. If people leave or an attitude of mistrust develops, the useful activity of the center will also cease.

Education Through Research

Research at universities ideally is used as a tool to educate students and faculty. A well-conceived research project that relates to real needs of users can provide an outstanding learning experience for both students and faculty. It allows students to take a project from conception to application, teaches students how to act on their own, and builds confidence. Research is a necessary component of graduate education and an important input to healthy undergraduate programs in transportation. Furthermore, the research experience of faculty also tends to form a basis for much of the teaching that takes place--faculty like to discuss their research and usually find ways to incorporate it into their courses. New concepts are developed and passed on to students who put them into practice. To maintain a quality educational program in transportation it is important to be at the cutting edge of new techniques and innovations. Forgive me if I discuss research at a conference on education; to me education and research are synonymous.

It is important for outsiders to recognize that "publish or perish" is a fact of life at universities. Tenure is awarded if you have a sufficiently long list of publications in scholarly journals behind your name. It is hoped that good teaching is also a necessary condition as well as a commitment to public service. The pressure to publish, unfortunately, results in a significant amount of useless drivel that is seldom if ever read by anyone. There is very little if any contact with the potential users of the work. Problems are defined that do not exist, methods are proposed for which there are no data, and results are described in a language that no one understands. This is a serious problem and we need to pay much more attention to the process by which research gets used and we need to develop better techniques for information transfer.

Tenure is a necessary part of the concept of free inquiry and can be critical for university faculty who choose to speak out on transportation issues. Those who have tenure should take advantage of their freedom and use a wide variety of techniques to better understand real-world needs, to perform relevant research, and to get the word out to the people who can use it. The freedom to investigate a variety of topics and to work without outside pressures provides an opportunity to make a better world. We need to exercise this right more often.

Deregulated Industry

In some ways the overall picture of university education in transportation is similar to that of a recently deregulated industry such as the airlines. We have a group of schools that could be called "the established carriers" in that they have been involved in transportation education for a long period of time. Like the established airlines, some of them are set in their ways and live on their reputations. They are not necessarily eager to move in new directions and gradually fade from the scene as they run out of things that they can do. Others continue to have strong programs over time because of a fundamental commitment to the discipline by key individuals. There is a second group of schools that could be called the new entrants. Some of these enter the market and leave after a few years whereas others remain. The new entrants generally are more willing to explore new directions and new concepts, and some of the best students and best work appear to come from these universities. This openness and competition is a positive aspect of university work in transport. Competition forces us to be creative and innovative and leads to better results and higher quality educational programs.

It is difficult to maintain an atmosphere of creativity and innovation at a university over a long period of time. It is my belief that, unless steps are taken to change it, the half-life of a creative organization (or even an individual) is about 5 years. In other words, about one-half of all innovation that will ever occur, occurs in the first 5 years, then 25 percent in the next 5 years, 12.5 percent in the next 5 years, and so forth. To maintain a high degree of effectiveness over time, deliberate steps must be taken to resuscitate creativity and to move in new directions. There is a real danger in overspecialization, and we need to ensure that there is a good population of generalists working in transportation at the universities.

PROBLEMS

All is not well at our universities these days. Over the past 5 to 10 years there has been an erosion of quality at many institutions. Morale is low and the situation is bleak. In the area of transportation, we have some serious problems as well. These relate to the job market for our students, the level of support for our programs, and the issue of relevancy. These are discussed next.

Job Market

The job market for transportation students who graduate from our universities is a major problem. This is a result of both the instability of the job market as well as the poor competitive position of transportation agencies as compared with other technical or managerial employers. Although hard numbers are difficult to obtain, it appears that the number of job openings for transportation graduates has fluctuated widely over the last several years. A few years ago no one appeared to be hiring new graduates, and students had difficulty finding a job. Recently there appears to be a big increase in the demand for students, and suddenly we are receiving calls from all over seeking our students. This is probably a result of two factors: first, the increase in highway and transit funds because of increased fuel taxes and second, the beginning of a retirement bulge of World War II veterans and GI bill engineers. It is hard to run a program over a period of years with the kind of fluctuations that have occurred in the job market.

The second aspect of the job market that is a problem is the relatively low salaries for starting positions. Top students can obtain jobs in electrical or mechanical engineering, computer science, or accounting at salaries $5,000 to $8,000 per year higher than beginning transportation professionals. In most cities the bus driver is paid more than the transit planner or beginning manager. Transportation agencies do not have competitive salaries for top technical people and these people go elsewhere. Fortunately, there appears to be a core of good students who singly like transportation and are willing to work in the field in spite of the relatively low pay. The relatively low pay scale means that many people enter the transportation field with little if any technical background. This situation presents an urgency for universities to become more involved with continuing education and new formats of instruction.

Support for University Activities

The characteristics of support for university activities at universities gives rise to what I call the Tarzan Syndrome. University faculty who are dependent on outside support for their work and for their students are like Tarzan swinging through the jungle on vines. They receive a contract or grant to conduct a project and leap off into the abyss not knowing what lies ahead. Sometimes they nicely swing through the jungle and land in another tree where another vine awaits them. Other times no tree awaits them and they crash to the ground where they have to pick themselves up and climb another tree. Still other times they become entangled in the vines and never get anywhere. We find that there are far too few vines for all of us in the jungle and that we have to use quite a few vines to get anywhere. Some give up easily and decide to leave the jungle whereas others keep climbing trees and falling down and maybe learning how to pick vines that take them somewhere.

This basically is a description of the funding situation for transportation activities at universities. We generally work on projects of 12 months' duration at the most, with little assurance of where the next project is coming from. Competition for projects is intense with a 1 in 20 chance of being funded for some programs. Outside funding is the key to maintaining quality educational programs in transportation because it helps to recruit good students and can build a commitment to perform and to innovate. The total funding level is terribly inadequate. Costs of all components of support have risen dramatically while funding levels have remained the same or declined over the years. For example, in 1970 the Urban Mass Transportation Administration (UMTA) university program was funded at $3 million per year or 1.7 percent of the total UMTA budget of $176 million. If one-half the money were used to support graduate students (applying rates used at the University of Wisconsin, Milwaukee), this $3 million would have supported 265 graduate students per year. During the past fiscal year, the UMTA program was funded at $2 million or 0.05 percent of the UMTA budget of $4.2 billion. This is equivalent to support for 66 graduate students. That is a 75 percent decline in the number of students we can support and a 97 percent decline in the share of the budget. At the same time the University Research Program of the Office of the Secretary of the U.S. Department of Transportation has disappeared.

During the past 15 years, there has been a major growth in the level of public support for our transportation systems. At the same time, there has been a significant cutback on the resources available to educate the people who plan, design, and manage these systems and ensure that the public's money is well spent. This appears to be penny wise and dollar foolish, and unless steps are taken to substantially reverse these trends, we are all wasting our time here.

Some schools have been able to get along through the support of their state departments of transportation or by successfully competing for contract work with consultant firms. Although such work can certainly be desirable, there is the potential for a loss of independence and freedom of expression if that is all an institution can do.

The support base of the universities is in a dismal state. Zero percent salary increases, disconnected phones, no secretaries, and travel freezes are all occurring at universities. Quality university programs are similar to bridges that tie together theory and practice. But like bridges, if they are not maintained they deteriorate and crumble until it is a hazard to send anyone near them. We need to rationalize and redirect our support programs for universities. We need a longer range view, more stability, and the effective use of competition to improve the quality of our education and ultimately the quality of our transportation systems.

Relevancy

The issue of relevancy is an important one at our universities. There are two sides to it and universities are continually wrestling with it. On one side we want to preserve the concept of free inquiry and have the flexibility to explore some topics in depth. There is a value in being academic and not being forced to be practical at all points in time. Universities are probably the only place where basic knowledge and sound theory can be developed independent of outside pressures, and we need to ensure that this is not lost.

The other side of the relevancy issue is that some universities are too far out of touch with the users of their products and have lost the capability to do anything useful for the transportation industry. We do basic research and are forced to call it applied. We do applied research without ever talking to the people who will apply it. We teach people to do things we have never done ourselves. We write reports that no one can read or understand, and our time is divided into so many little pieces that we have difficulty ever completely doing anything well. Like the old story of the emperor's new clothes, our king is naked in that we have reached the point where no one can see any substance in what we do.

We need to return to an earlier time when education and practice were closer to each other. We need to develop ways for university people to develop closer contact with the users of their product. We need to work harder to ensure that our results are relevant and usable. There are some schools that have done a good job of keeping their programs relevant, and there also is a place for pure basic research and study in transportation. We all need to look at ourselves and understand our purposes and goals to ensure that they are rational for our institutions and to see that we have a proper balance between theory and practice.

FUTURE DIRECTIONS

As we take this opportunity to examine transportation education, I would like to present some views on directions to take in the future. My suggestions will be of a general nature, and I do not mean that all universities should be doing all that I suggest. Each of us has a niche to fill and we need to do what we believe we can do best. In terms of overall directions, I see the need to develop closer contacts with the users of our work, the need for a more rational funding base, and the need to place greater emphasis on innovation and creativity.

User Involvement

There is a need for those involved in transportation education to recognize more fully the importance and complexity of technology transfer as they develop and implement their programs. Utilization of our products should be viewed as an important component of all stages of the educational process. Research and education should be conducted with a clear understanding of who the potential users of our products are and what their needs are. We should ensure that research activities have a legitimate educational purpose.

Ideally, research should involve potential users in problem definition, in the development of work statements, and in the conduct of research. Expanded mechanisms for greater user involvement in research and education should be developed and tested. Results of the research should be field tested and disseminated in accordance with a comprehensive plan for dissemination that recognizes the capabilities of potential users to understand the information. Finally, efforts should be made to obtain feedback from users and to update the results to keep them current.

There is a need to view the market for transportation education on a segmented basis. Different types of users have very different needs and, whenever possible, these needs should be addressed separately. Research can be conducted for use by other researchers (basic research) or for application in the field. The needs of rural and urban areas, different modes, engineers, and managers differ. Before dissemination materials are prepared, the potential audience for that material should be identified and the needs of the audience should be the basis for identification of a dissemination strategy.

One possible way to increase user involvement would be to develop short-term residency programs on university campuses whereby professionals could spend a couple of months on campus in a mixture of learning and project experience. On the opposite side, more opportunities are needed for faculty to work for agencies during the summer or to work on a part-time basis. We need to be able to bring experienced practitioners into the classroom more often and we need to develop ways whereby they can help us design our programs.

Continuing Education

Special emphasis should be placed on the future educational needs of practicing transportation professionals. Because of the increasing competition for highly technical personnel from other fields, it is likely that future entrants into the transportation profession will not have the level of skills that their predecessors had. This will result in a need for more extensive on-the-job training activities and better continuing education programs. This training activity should not only cover basic skills but should also be used to introduce new concepts to students.

This is not as easy as it sounds. A statistics course cannot simply be taught to a group of engineers. Quality continuing education takes a great deal of effort. As a provider of continuing education you must

1. Clearly understand the needs and capabilities of the students;
2. Understand the limitations on their time and budgets and carefully market the programs;
3. Work hard to link the programs to regular campus activities;
4. Prepare material that is clear, concise, and usable;
5. Present the material in an interesting and entertaining manner;
6. Involve students and let them learn by doing;
7. Permit students extensive interaction with each other and with their instructors; and
8. Carefully evaluate the programs when they are over.

In short you need top-quality teaching. It is not easy to develop such programs, and the competition can be stiff. Most successful continuing education programs rely on repeat business and word of mouth endorsements. Poor programs do not last long.

The benefits of a quality continuing education program with a strong link to regular campus activity are many. I know of no better way to determine the needs and capabilities of people currently working in transportation. Research and regular teaching improve because you have a better understanding of reality. Immediate results can be observed as students in short courses learn concepts that they can use the day they return to the job. Finally, you have the opportunity to meet people who are enthusiastic about learning and fun to be with. Not all universities should engage in continuing education, but it has an important role in the future.

Restructured Funding

Earlier I discussed the difficulty we all have in obtaining support for research projects. There is a need to restructure the support system for our programs. Obviously the overall level of funding is too low and needs to be increased. But beyond that, we need to examine the format and direction that the increased support base should have. I would suggest that the funding programs for universities be restructured along the following lines:

1. A legitimate basic research component. At the present time basic research in transportation is essentially not permitted. All work needs to be justified on the basis of how it will be used. People have been forced to call their research applied when it is really basic. I think we need to recognize the need for good basic work in transportation and support it.
2. Open competition. It is important that we maintain an atmosphere where all who wish to can compete for funding for their projects. Large schools, small schools, public, private, individually or a consortium, all should be allowed to compete. There is real danger in requiring a large sum of money to be put forward or a large matching contribution to be made in order to submit a proposal. Small schools should be allowed to compete and should have direct access to programs without having to be a member of a consortium to do their work. The rules should be made clear to all and the best should be allowed to rise to the top.
3. User involvement. User involvement as described earlier is an essential ingredient for successful work in transportation. The users of university work should be involved in problem definitions and should have input into other phases of the work. It is important that the ultimate users of the work be identified and are involved in the project. (It should be noted that even basic research has users, which would be other researchers.)
4. Longer term commitment. It is difficult to continue working on a series of 12-month contracts without ever knowing where the next project is coming from. Student recruitment, internships, and faculty development are very difficult in this type of situation. Multiple-year commitments are needed in order to provide greater stability.
5. Freedom of inquiry. We need greater flexibility in how we specify what is to be done. Research involves risks that sometimes pay off and other times do not. We need to be able to put good people to work on relevant problems. There is a need to ensure that the problem is clearly understood by all in the beginning, but subsequently we need the freedom to explore.
6. Increased funding. None of the preceding guidelines makes any sense if the current funding levels are not changed. We should decide which portion of the money spent for transportation is spent for university research and stand firm in our commitment. There is no future for university educational programs in transportation unless this is done.

Innovation and Creativity

These are words that everyone favors but they are often difficult to accomplish. We need to revitalize our universities as sources of new ideas and approaches to dealing with transportation problems. Members of the class of 1988 who are now beginning their studies will spend most of their working life in the first one-third of the 21st century. We need to try to determine what the world will be like then and work to provide them an education that will help them shape the world in the 21st century. How will people communicate and exchange goods? How can we better fit highways into a human environment? How can we effectively move large numbers of people? How do we deal with shortages of resources and limits to growth in the future? All of these questions and more are questions that we should be forcing our students to consider.

In the future we will have tremendous computing power at our fingertips and we are only beginning to understand what this will mean. From an educational point of view it means that we need to place more emphasis on teaching people how to think and use information instead of teaching them how to calculate. For example, soon we will have sophisticated computer-aided design (CAD) systems for highway and geometric design that will do most of the work now done by engineers. There are tremendous opportunities to use such tools in a creative process to optimize design in a human environment. Universities should be leading the way in learning how to use these tools in new ways and in teaching students how to work with them. The computer revolution probably also means that we do not have to spend a lot of effort polishing algorithms in our research, but on the other hand we need to find clever and inexpensive ways of collecting good data to feed into the machine. We also need to examine the potentials and applications of computer-aided education. It is now possible to design interactive learning packages and tools that provide all types of opportunities for off-campus instruction and whole new patterns of learning. More emphasis will be needed in developing managerial and human relations skills because it is becoming obvious that this will be critically needed in the future.

Innovation and creativity and an atmosphere where they can occur are the key to the future of transportation education. I hope this conference can produce recommendations to develop a future where our universities can play a major role in providing creative people who can shape the world into a better place in which to live.

SUMMARY

Transportation education in the United States follows an interdisciplinary approach with a relatively small level of effort overall. Programs are generally small and diverse and operate between established departments and interdisciplinary centers. There is a continuing process of schools entering and leaving the field as schools attempt to develop and maintain research programs to support educational activities. Many serious problems affect the transportation educational programs. These include a fluctuating job market, lack of competitive salaries for technically skilled graduates, an unstable funding base that has fallen far behind the level necessary to maintain quality programs, a loss of relevancy, and very little opportunity for free inquiry into long-range issues facing transportation. These problems are serious and need to be addressed. Some ways to deal with them include: greater input by the transportation community into educational programs, increased emphasis on continuing education, restructured and expanded financial support, and, finally, greater emphasis on developing innovation and creativity skills for our graduates.

Transportation Education: Technical Training and Continuing Education

David J. Cyra

> To the carrier and the shipper, transportation is a knot of government red tape that can be untied only by lawyers, tax consultants, and lobbyists. To the poor commuter, it is a road to hell paved with good intentions. To the cities which need better transit systems, it is a desire named streetcar. To the air traveler, transportation is the friendly skies full of fast planes, slow ticket counters, and hundreds of suitcases that look exactly like his. To the social scientists, of course, transportation is an intermodal, multi-purpose capability inherently responsive to the parametrical methodologies of interfacing disciplines. (Alan S. Boyd, former Secretary, U.S. Department of Transportation, 1968)

The rapid growth of transportation systems during the past 3 decades has posed unique challenges to transportation education in the 1980s. On the one hand, practitioners still need to be grounded in the technical skills offered, usually in academic disciplines such as engineering and urban planning. However, expanded service demands, coupled with financial constraints and complicated employee relations, make it essential that these same practitioners acquire the managerial skills necessary to run cost-effective, employee-efficient systems. In addition, the constant change and proliferation of technology, most notably in the communications and microcomputer fields, mean that transportation professionals must regularly participate in continuing education and technical training programs. This paper concentrates on continuing education and technical training and offers guidelines for how such programs can both reinforce and complement traditional academic courses.

INTRODUCTION

> The most important thing about education is appetite. Education does not begin with the university and it certainly ought not to end there. (Winston Churchill)

In both the formal literature of transportation education and the informal discussions heard at meetings, there appears to be a confusion growing as to the distinctions, if any, between the terms continuing education and technical training. For whatever reasons, continuing education is associated with instructional overviews, that is, generalized, abstract learning, as opposed to hands-on or simulated learning. Technical training, on the other hand, is considered to focus on the specific skills, knowledge, and behavior needed to accomplish day-to-day tasks in the workplace.

As the skill needs of transportation professionals have changed, however, the line between these two terms has become blurred. In short, there is a feeling that all professional education and training should share the best characteristics of these two concepts and that the terms should merge. In other words, the formerly static concept of continuing education should now include rigorous, hands-on learning that simulates real-life job situations, whether these situations be technical, interpersonal, or managerial. Likewise, the term "technical" in technical training should refer less to the content of courses, than to the manner in which it is treated. For example, a communications skill, such as speech-making, can be treated technically by defining its components in a step-by-step analysis.

Throughout this paper, then, the terms continuing education and technical training are used interchangeably to mean a type of professional education that seeks to simulate the managerial demands of the workplace and enrich the student participants with skills they need to face ever more complex demands for efficient operations and planning.

There are many catch phrases in the air today that emphasize the importance of continuing, relevant education for professionals in all fields. Maintaining professional vitality, career planning and management, human resource development, and so forth, are essentially similar concepts. They express in a positive way the situation experienced by both transport employees and employers, that is, their need to maintain knowledge and skills over a career span. Because, however, it is unrealistic to expect that any single undergraduate or graduate program could possibly be so comprehensive as to completely prepare the graduate for each and every professional situation, some type of continuing education or training appears to be mandated. What form this training should take is debatable. One way to establish it would be to take a systems approach and construct a continuing education working model.

A SYSTEMS APPROACH (1)

> Although a man's work may indeed be a good clue to his personal and social fate, it is a clue that leads us--and the individual himself--not by a clear and unique track to a known goal, but into a maze full of dead ends and of unexpected adventures. (Everett Cherrington Hughes)

Continuing education for transportation can be divided into five distinct but related categories:

1. Inquiry. At this point the transportation community communicates or exhibits a question or problem.
2. Needs Assessment. Continuing education professional (CEP) works with the community to determine the nature and extent of the developmental needs.
3. Program Development. CEP identifies appropriate instructors and, with their input and that of the potential users, sets specific training objectives, appropriate site(s), and length of session(s).
4. Instruction. Strictly speaking, this refers to course implementation; however, the instruction period is also a fruitful time to gain insights into addi-

tional training needs (inquiry), determine the extent of the problem (needs assessment), and determine the types of people who could best address those needs (program development). From a systems point of view, it is here that the seeds of the recurring cycle are shown.

5. Work-site Performance. Participants return to their job environments with enhanced skills. One goal of any such training would be a heightened ability to identify additional training needs as the workplace changes, thus initiating the cycle again with an inquiry.

6. Training Evaluation. Performance evaluations at all stages of the system are essential. At what point they are done is less important then that all facets of the training are fully covered. In practice, much training evaluation is done as part of the instruction. Some items that can be measured at this stage include (a) content, (b) relevance of perceived needs, and (c) presentation of materials to participants. Such evaluations should be performed by (a) participants themselves, (b) speakers (by means of pre- and post-tests), and (c) impartial observers trained to observe teaching and learning styles. In order that the systems cycle be complete, performance evaluations should seek to measure how much participants' colleagues and superiors believed the training contributed to company or agency operations.

Those of us who consider continuing education planning as a major professional activity might ask ourselves the following questions during a systems analysis of our activities:

1. Inquiry

- What recurring questions or problems are evident in the transportation community I serve?
- Who currently perceives these situations as problems (only me, management, labor, outside agencies)?
- If a continuing education or training program were to address the problem, what would be the characteristics of the appropriate students or participants?
- What people and groups set the standards for these students for knowledge, skills, and performance?
- What role does each source of influence play that I should be aware of? How do they communicate? With each other? With the potential students?
- How do I keep aware of people, trends, and events in my community?
- What is the general level of need at the present time?

2. Needs Assessment

- Which people and groups evaluate the potential students? What assessment methods do they use?
- What strategies are appropriate to assess the students' current skills? How do I use the data obtained?
- What role do I have in the assessment process?
- How is information about students and needs communicated to continuing education teachers?

3. Program Development

- Which people and groups is it appropriate to include in planning the overall learning experience?
- What roles do each (including myself) play?
- What decision-making methods are used for the following?
  - (a) Learning goals and objects;
  - (b) Selection of resource persons and students; and
  - (c) Development of curriculum, teaching methodology, and assessment procedures.
- Are alternatives fully considered?
- How is the final plan to be approved, implemented?

4. Instruction

- Who are the major participants in the instructional phase (students, speakers, observers or monitors, facilitators)?
- What roles do each play? What is my role?
- Who has the primary responsibility for monitoring and control at this stage? How do I fit in?
- How is performance measured and should results be used?

5. Worksite Performance

- Who is responsible for post-training evaluation and assessment? When and how often is it done?
- Do I have a potential role at this point?
- What will be measured at this point and which techniques will be used?
- How will this evaluation-assessment be validated?

6. Overall Training Evaluation

- Did the instructions and training meet the perceived needs of the students? Their employers and superiors? The goals of the instructors and CEPs?
- Were all relevant members of the transportation community included at each stage of the training?
- During the instruction phase:
  - (a) How much time was devoted to student participation, straight lecture, hands-on experience and/or simulated work situations?
  - (b) Was the physical environment conducive to adult learning?
  - (c) Did the leaders and teachers respect the opinions of the participants?

Although this systems approach is a good way to analyze the cycles of professional training, the question remains as to who should be in charge of the cycle. Traditionally, each separate profession has taken the responsibility for continuing the professional training of its members. However, studies of both knowledge transfer in general, and continuing education in particular, indicate that there are many attitudes and skills shared by all professions. All professionals, whatever the field, indeed all people, whatever the job, need specific problem-solving and communications skills to relate well to peers, subordinates, and superiors and to effectively present themselves and their ideas.

It is wrong to define job skills too narrowly. In transportation, a multidisciplinary field that draws its members from many professions, bus drivers, planners, and engineers all need communications and marketing skills; they simply use the skills to different ends. Although specific technical knowledge may vary from financial planners to maintenance personnel, the way they manipulate that knowledge in the current age of microcomputers can be similar.

In addition, in transportation, "who does what" varies considerably from state to state, from urban to rural transit. It is dangerous to think categorically about what an engineer does as opposed to a planner or a manager; a maintenance worker as opposed to a bus driver. Moreover, in certain systems, the engineer, planner, manager, maintenance worker, and bus driver are all one in the same.

From the preceding discussion, it appears more practical to structure continuing education training around the similarities, rather than the differences, among fields. Two ways to approach this would be to (a) discuss theoretically the three ways all people learn (basically through the modes of inquiry, instruction, and performance) and to (b) discuss the specific orientations all professions share.

THE THREE MODES OF LEARNING (2)

> From the literature, the practitioner learns the rules; from experience, the ways in which they should be applied (2,p.45).

In structuring a continuing education program, planners will inevitably use one of the three traditional paths to learning. Ideally, continuing education training will be a collaborative effort among skill builders, students, employers, and educators. In structuring a continuing education program, these planners should probably use all of the three classical learning situations discussed next.

Inquiry Mode

This type of learning is often used in situations in which the outcomes are uncertain--establishing goals, working out compromises, projecting plans. It is a process of developing new ideas, policies, procedures, and so forth, using techniques such as discussion and encounter groups, seminars, clinics, brainstorming sessions, and the like. Such learning often cannot be evaluated immediately, but must await the future realization of projects goals.

Instruction Mode

The instruction mode is what many people associate with traditional teaching situations--the dissemination of established skills or knowledge. This dissemination can require either passive or active participation from students. Most people concerned with positive educational experiences for learners, whatever the subject or level, agree that the more active the participation by students (such as group problem solving, simulation, or role playing), the better the learning.

In the instruction mode there are specific skills and information to be mastered. Such mastery can be evaluated throughout the learning process by any number of formal and informal means.

Performance Mode

This type of learning is achieved after both the goals set through inquiry and the skills demonstrated through instruction are internalized by habitual professional activity. Evaluation of this mode is performed by peer groups, professional associations, and government examiners.

What these three modes of learning mean for continuing education can be stated simply. Each profession is constantly challenged by new discoveries, new technology, and new techniques. To change outmoded practice, the leaders of the profession, either on their own or at the prodding of public and government groups, must initiate an inquiry as to how best to incorporate new ideas into the profession as a whole. Once specific goals are set, current and aspiring members of the profession can be instructed in general and specific applications. Concurrent with this instruction will be the development of performance measures so that professional standards can be maintained after instruction is complete.

It appears obvious that, if they share nothing else, the various professions could at least collaborate in refining techniques and strategies for inquiry, instruction, and performance as these relate to adult professional learners. However, I believe the various professions, both within and outside of the field of transportation, share a potential for a much greater collaboration.

COMMON CHARACTERISTICS OF PROFESSIONS

> Just as the whole world is a school for the whole of the human race, from the beginning of time to the very end, so the whole of his life is a school for every man, from his cradle to the grave. . . .Every age is destined for learning, nor is man given other goals in learning than in life itself. (John Amos Comenius)

In Power and Conflict in Continuing Professional Education (2), Stern introduces a new concept to replace the static, elitist values he perceives as traditionally associated with the notion of the professions. Instead of specific, fairly well-defined exclusive professions, Stern outlines certain professionalizing attitudes and activities that can characterize workers in any occupation (2,pp.33-54). The degree to which the occupation's work force shares in these attitudes and activities becomes the constant measure of its professionalism.

Certainly such an idea is particularly appropriate in transportation, where transit and highway managers often come up through the nonacademic ranks. It is likewise appropriate as transportation receives greater percentages of public monies, because such federal and state support mandates broader service orientations. Finally, such a notion is very much in tune with the ideals of quality circles and team dynamics currently making the rounds in training seminars.

What, then, are some of these attitudes and activities that characterize professionalizing occupations?

1. A constant redefining of the mission and theoretical framework of the job: Why do it? In transportation one such redefining has led to an emphasis on the rights of the handicapped to accessible public transit.
2. The second professionalizing characteristic is the need for continual problem solving: how to build a better mousetrap. Whether it is how to run well-maintained buses, how to bring a dissension-wracked agency into harmony, or how to build a bridge in difficult terrain, the professional is constantly trying to find new ways to do things better.
3. A third professionalizing attitude is the constant relating of theoretical knowledge to worksite practice: how to relate the learning to the job. Professional literature supplements but cannot replace the education acquired from actual practice. From the literature the practitioner learns the rules; from the experience, the way the game is played.
4. Personal improvement or self enhancement is the fourth characteristic of a professional. Such improvement is not limited to obvious job-related skills, but extends to such areas as art, music, and so forth. Intellectually, there is no sharp delineation between occupational talents and extra-occupational skills. Many forms of outside-the-job learning can have definite, practical career bonuses by bringing new outlooks and clients into focus.
5. Communication skill is the fifth characteristic of a professional--the ability to persuade others of the utility of new ideas and products. In a work world that is constantly changing, communication skills are necessary to prepare for and adjust to new technologies and orientations.
6. The sixth characteristic is service-related: the need to bring tangible benefits into the lives of others. Certainly, as transportation becomes increasingly dependent on public funding, the service orientation of the profession must increase proportionally. Any continuing education and training must take this into account, especially by providing ways to measure these benefits.

The real professional is aware of the need and force of change and welcomes change as an opportunity to improve performance. This is true whether the professional is a doctor, a transit manager, or a bridge builder.

PRINCIPLES OF ADULT LEARNING

> Where my reason, imagination, or interest were not engaged I would not or could not learn. (Winston Churchill)

Bryant (3) has identified seven principles of adult learning that should be considered here. They correspond to general principles of information transfer that hold true for all communication.

1. Learners must want to learn; they must view their learning as somehow personally essential. The role of the continuing education professional is crucial here because he or she can directly control this motivation. One way is by sensitively matching the learning to the learner and by making the workplace relevance explicit. Another is by selecting appropriate instructors; those who will win the respect of the students without alienating them by failing to respect their experience.
2. The learning environment should be characterized by physical comfort, mu-

tual respect, freedom of expression, and acceptance of differences. Physical comfort covers a lot of ground. It includes spatial factors such as lighting, elbow room, and sufficient breaks, as well as ventilation, plenty of visuals, and handouts that synopsize major points so that students are spared the pain of taking notes. Mutual respect between students and instructors is especially important when, in many cases, the students will have direct experience with the problems under discussion and will have great potential as additional resources. For the same reason, students must feel free to both disagree with and supplement the teaching with their own opinions.

3. The students must perceive the goals of the learning experience to be theirs. Here, too, the CEP plays a potentially important role. In the earlier discussion of the stages of the continuing education cycle, program development was mentioned as a major part of the process. When a transportation need has been identified, the CEP must carefully structure the learning to fit that need and target it to the correct student learners. He or she does not do such planning in a vacuum, but in collaboration with practitioners, employers, and potential instructors. If the relevance of the learning is made explicit and the particular objectives of each part of the instruction is made sufficiently clear, students will have no trouble embracing the learning goals.

4. The learners must accept a share of the responsibility for the planning and implementation of the learning experience in order to have a commitment to it. As in principle 3, the role of the CEP as a facilitator is crucial. Recent studies of information and technology transfer show that potential users should be included at each step of research designed for them in order that their input and interest is guaranteed. Likewise, potential students, the ones with firsthand knowledge of the particular problems the learning is attempting to solve, cannot be ignored in the program planning stage.

5. The learner should participate actively in the learning process. Only by actively engaging the students, whether by simulations, hands-on practice, or group discussions, will an instructor be successful. Here, too, the CEP can exert a powerful influence. He or she can ensure that extra-classroom activities are planned to encourage students to get to know each other. Ideally the students will be peers, with much in common beyond the problems under consideration in the classroom. If students are comfortable with each other outside the classroom, they are less likely to be shy with one another inside it. Such good social vibrations not only improve the learning atmosphere in the classroom, but also provide opportunities for the learners to form networks for future information exchange.

6. The learning process is related to and makes use of the experience of the learners. Postman and Weingartner, in *Teaching as a Subversive Activity* (4), make the point that "we can, after all, learn only in relation to what we already know." The adult learner processes new information through a mental screen of his or her own experience. This has several implications for the CEP. Every student will not, for instance, have a common experience window either quantitatively or qualitatively. Such variety makes them valuable resources for one another. An effective instructor will be able to take these experiences, both good and bad, and use them as the specific examples of the points he or she is making. Both as a social ice-breaker and as a valuable guide for the teacher, it is a good idea to have participants identify themselves at the beginning of a workshop or seminar and describe their work responsibilities and what they hope to obtain from the learning experience.

7. The learners have a sense of progress toward their goals. Students can only make progress toward goals that are already defined. The CEP can help adult learners set these goals for both the short run of an individual course and for the career long term.

THE CONTINUING EDUCATION PROFESSIONAL: WHO APPEARS TO FIT THE ROLE?

> Human service is the highest form of self-interest for the person who serves. (Elbert Hubbard)

The effective CEP is a strategist who designs learning environments (situations, events, activities) in which people are given opportunities to learn. Such environments should:

1. Provide an opportunity to practice or try out the new information;
2. Make it possible to apply the information to a complex problem; and
3. Show how the information can be applied to other, similar situations.

The CEP must be responsive to a complex transportation-related network that includes employers, public officials, university professors, government administrators, practitioners, transport community leaders, and users of transportation services. The CEP may play various roles within these groups, from information resource person to designer of short courses, as well as initiator of applied research. There is no single role that defines a successful CEP, but it is clear that he or she must be skilled at serving many masters.

As noted earlier, there has been some debate as to whether CEPs should come from the ranks of the profession itself, from universities, or from professional consultants. Where they come from is much less important than what personal skills they bring to the job.

One way to view the CEP is as a specialist in information transfer. After all, he or she must identify transportation needs, collaborate with practitioners, teachers, and transportation users to determine the nature and extent of the problem and to help communicate with students in solving the problem and meeting the need. Finally, he or she must evaluate how well the information presented served to meet the perceived need.

Peake (5), in a report for the National Aeronautics and Space Administration entitled "The Human Element in Technology Transfer," outlined the personal characteristics necessary for a successful information transfer specialist. They certainly apply equally well to the CEP who is also involved in altering current behavior patterns and initiating change. Following is a list of questions to ask when selecting a continuing education professional.

- Sensitive: Can the person relate well to the very different types of people found in all echelons of the transportation community, from corporate moguls to cab drivers? Can he or she speak their very different languages?
- Motivated: Does he or she have a genuine interest in serving others, and the self-discipline necessary to work independently in difficult circumstances?
- Analytical: Can he or she identify problems and measure their extent?
- Cooperative: Is he or she a nonauthoritarian who does not resent authority in others? Are his or her goals put at the service of client goals?

- Charismatic: Does he or she have the leadership qualities necessary to bring diverse groups into agreement?
- Flexible: Can he or she change behavior to meet varying demands and pressures?
- Aware: Can he or she see the social and political implications of information and situations?
- Disciplined: Is he or she able to pursue many different goals simultaneously without scattering resources? Is there honest inquiry and curiosity? Is time budgeted wisely?
- Imaginative: Can he or she be innovative in assessing needs, finding speakers, and structuring the learning environment?
- Persuasive: Can he or she present ideas effectively in speaking and in writing?

General Background

- Experience: Does he or she have sufficient breadth of experience to be able to relate to the diverse technologies of the workplace?
- Interests: Do his or her hobbies, outside activities, and community work demonstrate a variety of knowledge and a desire to serve?
- Education: Has he or she pursued a course of professional enrichment through some type of continuing education and training?
- Accomplishments: Are his or her achievements novel or routine? Did they occur frequently or in spurts? What honors has he or she been given? Does he or she have the respect and recognition of peers?

All of these attributes can be summed up under the general headings of human relations skill and intellectual competence; the human relations skill is the more important of the two. No amount of intelligence can make up for an inability to communicate.

ACTION PLAN FOR IMPLEMENTATION

Probably we would all agree that too few transportation professionals continue to learn throughout their lives, and that the continuing education programs currently available are fewer and less enticing than they could be. Transportation practitioners are not, after all, clamoring at the gates of continuing education. Whether this is due to a genuine lack of interest or to a failure of continuing education to adequately address their needs is debatable. We know, in any event, that the entire transportation community can benefit from relevant continuing training: the student can benefit from the advancement and confidence that comes from increased job skills; the employer can benefit from the increased efficiency the students bring back to the job; the transportation public can benefit from more streamlined service. The challenge we face, then, is how to make continuing education "a consummation devoutly to be wished," rather than a burden to be borne. Some actions that would help include the following:

1. The transportation professional associations should be encouraged to take increased responsibility for fostering a zest for learning among their members.

Students of any age must be motivated in order to learn, but this individual, personal motivation comes from a recognition of the value of the learning. These groups are ready-made resource networks the CEP can use both in assessing needs and in promoting training programs.

2. Continuing education planners should encourage professional attitudes and pride among all workers. They should make clear the relevance of their programs to the various specific transportation occupations, especially when these programs teach nontechnical skills not traditionally associated with the job. They should also place the training and the job in the larger transportation context so that a certain pride in working in the field is fostered.

3. A CEP who wants to be truly effective and efficient should consider taking a systems approach to structuring continuing transport education. He or she should take care that their continuing education programs result from a collaboration among all members of the transportation community, as well as professionals from outside the field with good skills to offer. A good exercise might be to record how he or she currently plans programs and to compare this with the activities described in all stages of the system cycle.

4. The three modes of learning should be taken into account when planning continuing education programs. Inquiry, instruction, and performance should all be incorporated into program learning. The best mix of these should be determined by collaboration among students, teachers, and employers.

5. Transportation professional associations should collaborate with employers and government agencies in planning and providing training. Although each separate occupation has its unique body of knowledge, each also shares many information and skill needs with the others, even some outside transportation per se. Greater collaboration could achieve substantial financial economies and could help ensure better quality and program effectiveness.

6. The principles of adult learning need to be incorporated into program development of continuing education courses. The traditional lecture simply does not work well with adult learners. They need to believe that their opinions and experience are respected and that there is confidence and trust between teacher and student.

7. The continuing education professional is, in a sense, in the information and technology transfer business. Many of the personal qualities appropriate for a transfer specialist are also those of an effective CEP. Probably the most important of these is an ability to communicate and relate comfortably with many different kinds of people.

The final point I would like to make is that continuing education should be considered the responsibility of each member of the transportation community, not just a select few. The identification of needs and a program to meet those needs cannot be done by any one person or group, but must come from a natural collaboration of all segments of the community. Working together we will achieve far more than the sum of our individual efforts.

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Efficient Utilization of Transportation Research and Educational Resources

William M. Spreitzer

In beginning to cope with today's lack of transportation research funding, Wilfred Owen might begin by quoting from Charles Lutwidge Dodgson, the English mathematician and logician (better known as Lewis Carroll) and author of Alice's Adventures in Wonderland. Robert Herman would recite a delightfully appropriate and somewhat irreverent limerick. Paul Roberts would tell a homespun story--probably about a young lad with a frog in his pocket--and poke fun at Henry Bruck's necktie. Others of us would organize a task force or form a committee or write a technical paper or journal article. But in a word, transportation educators, researchers, and practitioners are "concerned" about the level of financial support for transportation topics.

Experience and history tell us that the pendulum will swing. Improved funding, interest levels, and demand for specially trained transportation research personnel will surely return. The challenge in the interim is to make more effective and creative use of existing resources (people, dollars, and services in kind). Services in kind are contributions of data or computer time or other resources that defray project expenses. Such services might be used as matching funds.

The purpose of this paper is to identify and discuss innovative funding sources for transportation research in an era of scarce funding. To assist in this discussion, several distinctions and premises are proposed:

1. Demand for trained personnel should lead supply in order for an adjustment to occur.
2. Fundamental conflicts exist between research objectives and more applied opportunities. These conflicts are more problematical for university faculty and staff but exist within industry and government laboratories as well.
3. Although industry and private venture funding have been required to provide increased support for basic research in the current economic climate, the responsibility for major support for basic transportation research remains with government (primarily at the federal level).
4. There is a distribution of skill levels and motivations among research personnel. The most highly skilled and motivated will almost always have support; the least capable dilute available resources and should be weeded out. The greatest funding challenge is for the larger group of investigators in between the two extremes.
5. Griping and commiserating about the current lack of funding is counterproductive and wasteful. Instead, we need to justify our needs with good

work, solid preparation, a positive outlook, energy, productivity, and recognition that we get what we deserve.

DEMAND AND SUPPLY

There is a general shortage of highly skilled, highly trained people to conduct research. National Science Foundation (NSF) numbers indicate that U.S. universities conferred 3,400 Ph.D.s in engineering in 1970; 2,500 in 1980; 2,644 in 1982; and 2,780 in 1983. Of these, 354 were in civil engineering and 86 were in industrial engineering in 1983.

Personal experience as an employer and a recruiter indicates that the current supply is well below demand. Further, prospects for the future tend to be dim with one large private institution considering dropping the undergraduate civil engineering program because of lack of students. At several other universities, student-to-faculty ratios in transportation programs may necessitate a shift of faculty to other topics. Finally, high demand and good salaries for engineers with B.S. and M.S. degrees have siphoned off potential Ph.D. candidates.

RESEARCH OR CONSULTING?

The prime function of the university is education. The purposes of faculty and graduate student research are to develop new knowledge (which also retains the interests of the capable faculty needed for the basic teaching function) and to train students in how to approach and conduct research. There is often a temptation to blunt these purposes by applying resources for consulting or contract work of a short-term or applied nature. This is particularly true in times of financial shortages and declining markets for longer range research.

It is proposed that contacts made outside the university by faculty and staff members should include prospecting for support for more basic research. Successful applied research, consulting, or training services with a new client build exposure and credibility. As a result they represent opportunities to conduct more fundamental research.

There are the additional advantages in being there first--in frontiers of science or technology, in newly discerned needs, or in anticipated needs. Artificial intelligence and expert systems needs, and applications in logistics, distribution, routing, and scheduling are current transportation-related examples.

SUPPORTING BASIC RESEARCH

Who should support basic research? The responsibility rests with society and with government as the agent of society. Government and society agree that this is the case with science but attitudes regarding engineering vary. On the plus side, the NSF is considering long-term financial support of engineering research centers. NSF describes the purposes of such on-campus centers as "bringing together university and industry people to improve the education of those who will undertake the practice of engineering and expos[ing] a significant number of engineering students to the nature and problems of cross-disciplinary research or engineering systems" (1).

In the meantime, the continued decline in federal support and increased competition have spurred industrial and private venture interest in sponsorship of university research. Such support comes in many forms ranging from unrestricted, philanthropic grants to directed contracts with specialized faculty on specific studies.

One example is the Presidential Young Investigator Awards of the National Science Foundation (2), which are intended to provide research support to the best science and engineering faculty members and include participation of the industrial sector.

The awards are directed to helping universities respond to the demand for specially skilled research personnel in both academia and industry. The awards are for a minimum of $25,000 (over a 5-year period) but NSF will provide additional matching funds of up to $37,500 on a dollar-for-dollar basis with funds from industry. Thus potential support is up to $100,000 over a 5-year period, and prospects are excellent for client involvement and exposure.

About 55 percent of the General Motors and General Motors Foundation contributions in 1983 consisted of aid to education, including support for colleges and universities and scholarship and fellowship programs (3). Another example has been the designation of three universities as Affiliated Laboratories by the Association of American Railroads. The purposes of the financial support and commitment represented by these designations are threefold: (a) to retain competent investigator interest by partially replacing lost or declining federal support, (b) to provide for continuity and stability over a designated period of time, and (c) to make more efficient application of resources through local specialization and coupling through technical advisory committees, which include industry representatives. In some cases, portions of such financial aid from industry, associations, and foundations are available to perceptive, aggressive, and capable researchers.

TIMELY TOPICS

An example of the importance of timely topics both in gaining financial support and in assisting managers to make better use of available resources is the Strategic Transportation Research Study (STRS) (4). This study was initiated by the Transportation Research Board (TRB). Given the continuing decreases in research support, STRS was initiated to (a) identify high-value research topics (beginning with highways), (b) assess the prospective costs and benefits of research on those topics, and (c) recommend alternative approaches to getting the needed work done.

Other examples of timely topics include:

- Better use of existing facilities, for example, highway operations and transit operations;
- Freight operations and logistics;
- Applications of personal computers;
- Data needs; and
- Applications for artificial intelligence and expert systems in transportation.

Some may argue that traffic operations and transit operations (and consulting, as well) are not research. However, these topics need work and given good work and successful results they could lead to more research-oriented efforts when financial prospects improve or other somewhat related research needs arise with the same satisfied clients.

The topics of freight operations and logistics have surfaced as opportunities because of the rise in interest rates, the economic slump, which created pressures to find cost savings, and deregulation. In addition, as productivity improvements provide efficiencies in manufacturing, the proportion of product costs from transportation, material handling, and inventory expenses increase.

Despite significant strides already made in applying personal computers in transportation design, operations, and management, efforts to date only scratch the surface. Innovative applications await discovery and, once the idea is sold, training and software program improvements are follow-on possibilities.

Transportation data needs are of continuing concern (5). Vital to both research and applications, the collection, organization, and provision of transportation data represents opportunities for individuals and organizations.

INSTITUTIONAL ARRANGEMENTS

Joint ventures have many advantages in times of limited resources. Often services in kind can be provided by organizations collaborating on research areas of common interest. Two examples of services in kind are data and computer time. In addition, pooling of personnel can often provide a critical mass where any one of the joint venture partners could not manage sufficient staff alone.

Two subject areas that might afford opportunities for public-private-university joint ventures are (a) management science and (b) human behavior and traffic safety.

Substantial experience in business management by industry and commerce might be applied to government transportation management needs through university analysis and review. Cooperative highway safety research among manufacturers, government agencies, and universities would expedite the development of increased understanding of how people perceive and use safer transportation products. Such understanding could contribute to resolutions of drinking and driving problems and to increasing the level of seat-belt use and acceptance of mandatory seat-belt use laws.

Bootstrapping is another set of opportunities for getting started. Bootstrapping comes in many forms, including seed money grants from foundations or industry, building from support for other work in traditional areas (such as National Cooperative Highway Research Programs), or entering new areas through professional and technical societies such as the National Council of Physical Distribution Management.

Education and Training contracts can often lead to research support as the client and the contractor get to know the subject and one another better. Professional acquaintanceships can also be improved through faculty members consulting with industry and government or through sabbaticals with industry and government. In such arrangements everyone gains. The client gains through the availability of specialized knowledge, training, and capability. The faculty member gains through a broadening of experience and exposure to new, real-world settings. Perhaps most important of all, the students of the faculty members benefit from the enrichment in the knowledge and experience base of the teacher.

In addition, research work with industry is exciting and stimulating. Such work provides opportunities to prove theory, to demonstrate application potential, and to have the satisfaction of seeing one's efforts in actual, ultimate use. Such work makes demands on the realism of models and on research ingenuity and personal productivity, which are sometimes missing in a more abstract environment. Exposure to the clients also serves as a constant source of new research ideas.

Consulting in mature subject areas and with state and local government sponsors in addition to federal sponsors can often lead to support for research work in newly developing or frontier subject areas. For example, work in management, operations, and planning for transit agencies could lead to future, more basic work in marketing or in spare-parts inventory control for the same organizations. Finally, individual support from government, industry, or a trade association for a particularly deserving graduate student can often lead to continuing interest and support.

SATISFYING THE NEED FOR PERSONNEL AT THE Ph.D. LEVEL

The present shortage of personnel at the Ph.D. level will persist until funding improves. Mere demand for qualified personnel is not sufficient; there will be a lag in the supply. In the interim, sabbaticals (particularly for younger, perhaps untenured faculty and staff), reverse sabbaticals or trades of qualified industry or government personnel, and special scholarship or grant incentives from industry or government to particularly deserving, research-oriented graduate students would help. In addition, technology transfer programs that directly expose graduate students to industry and government needs might encourage pursuit of further graduate work.

Admittedly, persuading harried and worried administrators to dilute their scarce commodity by assigning people to possibly temporary pursuits will be tough to sell. But maybe the merits of the benefits will justify the attempt.

FUNDING SOURCES

With reductions in public agency support for research in transportation and in other important subject areas, private ventures have found it advisable to increase contributions in particular cases. Given the economic climate that has prevailed, support has focused on high-priority or promising topics. Foundations that focus on transportation include the UPS Foundation and the Eno Foundation.

Another time-proven source of seed monies is industrial affiliates. Transportation centers with affiliates who contribute a relatively modest annual membership fee have an assured financial base for helping young faculty members (plus an outside source of advisors for dissertation committees or for evaluating faculty and graduate student research).

As mentioned earlier, consulting and sabbaticals with government and industry represent an underused source of funding. The often-cited specters of patent rights and publication limitations are excuses and not impediments to partners working on important, interesting, and exciting topics.

One university faculty has proposed a variety of alternatives to the provision of critical research and equipment funds. One of the suggestions is for a student surcharge of $300.00 per term on every engineering junior, senior, and graduate student. The resulting funds would be used to replace or provide needed equipment and to support research within the traditional review and approval procedures.

SUMMARY

The present paucity of funding for transportation research is natural, temporary, and probably deserved. The shaking out of less capable investigators from the transportation research field is healthy. The challenge is largely for deserving investigators to do what is necessary to justify the importance and the value of their proposed work.

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Transportation Research and Its Link to Education

Robert E. Paaswell

Research is conducted to advance our state of knowledge on topics about which we are concerned. Transportation research, in particular, seeks answers to questions, theoretical and applied, concerning the way we move ourselves and the objects we work, live, and play with.

We live in a technological society. If we have a problem, we create a solution. For example, after World War II we understood the incredible drive for mobility in this country and we created the Interstate highway system--one of the engineering wonders of all time. The creation of the system was conducted with little research. Since construction of the system we have spent billions of dollars on understanding all the implications of that creation. Perhaps the highway system, in all its magnitude, can serve as a metaphor for transportation research. It combined short-term demands with long-term implications: it attempted to apply the most practical of solutions to all its elements while raising elements of the most theoretical type.

Why conduct research in transportation? People have always sought mobility and, not being individually self-sufficient, must also have ways to move goods. Transportation research at its most general level seeks answers to the following questions:

- What are the most efficient and effective ways of moving people and goods?
- How can the greatest benefits be derived from our means of transportation?
- How can the costs of providing transportation continually be reduced?

There are a number of corollaries to these questions.

- How can we move people and goods as quickly as possible?
- How can we move ourselves and our goods as safely as possible?
- How can we minimize the obtrusiveness of our transportation systems on our overall environment?

Social values, at various times in our history, have placed differing emphasis on these questions. Before we were concerned with the environment, we conducted research on highway safety and traffic flow, and, as a result built immense highways and interchanges for high-speed operations. We then followed with research in the land use impacts (dislocations as well as development) of these enormous pieces of construction.

Research in transportation arises as solutions are sought to urgent problems. The form the research takes, its scope, content, impact, utility, and the dissemination of the results are determined by the person that defines the research problem. Research can be theoretical or applied, can deal with issues in the short term or long term, can be elegant or quick and dirty. We are learning now that the breadth of research, especially university-initiated research, is determined to a great extent by the sponsor of the research. Such research problem formulation leads to some difficulties, yet it may also spur innovative solutions to problems by using approaches and mixes of disciplines not thought of 20 or 30 years ago.

Only one major aspect of transportation research is addressed in this paper--that research conducted at universities and colleges. Examined are

- The objectives of transportation research,
- The conduct of transportation research in an academic setting,
- Aspects of research needs and support, and
- The future of academically based university research.

Transportation research comes in many modes and disciplines. This paper is directed to highway and transit research and deals with research as viewed from a U.S. perspective.

OBJECTIVES OF TRANSPORTATION RESEARCH

Some of the objectives of transportation research are to

1. Solve a well-defined problem for which an immediate answer is needed (e.g., impacts of transit fare increases).
2. Help define the ranges and limits of a problem (e.g., land use impacts).
3. Synthesize or gain understanding of previous history in an area (e.g., behavior of fills in marshy areas).
4. Postulate new methods to address defined or emerging problems (e.g., travel demand).
5. Suggest new subject areas or approaches in a speculative way (e.g., communications; innovative propulsion systems).

To accomplish these objectives, organizations carry out a variety of studies, or research projects, of varying intensity and length and propose conclusions or findings. Transportation research is initiated throughout the transportation industry, in public and private sectors, in small and large firms, and throughout every level of government.

For the purposes of discussion, I propose that three basic organizational institutions are responsible for the conduct of research:

1. In-house research groups--part of the organization that identifies the problem and seeks the solution.
2. Consulting organizations--both profit and not for profit (both in-house groups and consulting organizations might include vendors of transportation equipment).
3. Educational institutions.

Each of these organizations is unique, with its own internal organizational requirements (Table 1). The problems addressed by each organization do not fit into simple categories, but these definitions outline the traditional roles.

What, then, is the appropriate contemporary role of university-based research? How can it (or should it) sustain its inherent uniqueness? What contributions can it make?

TABLE 1 Institutional Research Organizations

Organization	Characteristics of Research
In-house agency (non-research and development)	Part of firm or public agency; problems often short term, applied research orientation; quick solution with operational outcome demanded; problem payoff must be found; staff not necessarily full-time research staff
Consulting firm	Usually permanent capability in a defined area; responsive to client needs; fit research approach to client resources; able to produce intense levels of effort over specific time spans
Educational institutions	Multidisciplinary staffs with continuity of effort; more responsive to long-term problems; training of future professionals part of overall research effort; applications of state-of-the-art thought to problem solution

Theoretical Versus Applied Research

Academicians have the mandate to advance the state of knowledge in a given discipline. Traditionally, university research has been coincident with theoretical research. Theoretical research poses theories and hypotheses concerning behavior. Excursions into entropy theory, or utility maximization for travel demand analysis, or the application of the theory of elasticity to layered system theory for soil foundations have been primarily university contributions. Universities have the resources and the time to experiment and to postulate related problems, and they also have the luxury of trial and error that other organizations do not. Theoretical research implies postulation and experimentation while simultaneously demanding rigor. The nature of theoretical inquiry is one of the products that is given to young researchers (often graduate students) as they conduct research in an academic setting.

Applied research is more problem specific than generic. It seeks solutions to (not always) well-defined problems, and, as a product of the research, seeks prescriptions for the solution of problems. Examples of applied research that have a broad impact on transportation systems are the development and integration of the stress-path method into analysis of foundation structures (retaining walls, stability of embankments) and the new application of the development of new software for microcomputer applications in all aspects of transportation.

Applied research in a university setting should have a product that is meaningful in an academic context. Universities, in general, do not usually compete with consulting firms or testing laboratories for routine analyses, data collection efforts, or standard tests. The implication of applied research being conducted at universities is that the perspective of or approach to the work is unique, the information gained advances the state of knowledge, even if by a small increment, and the results can be published or presented.

RESEARCH IN AN ACADEMIC SETTING

The university provides a special setting for the conduct of research (Table 1).

1. Continuity. Universities are long-lived, generally conservative institutions. The structure and conduct of work at universities can generally be predicted, although the personnel might change. Disciplines develop and evolve, information is shared with colleagues, and program content is established; this is critical. The work of a faculty member spans teaching and research; there are no sharp divisions. The impacts of research find their way into a teaching program and are passed to a large number of students. Simultaneously, methods and theories tested in the classroom find their way into the operations of a research project. The method, or approach to work, is somewhat consistent across universities. The client can anticipate, now, or next year, how work will be conducted and disseminated. This continuity of approach is complemented by a continuity of content. In terms of continuity, this means that knowledge gained previously from a study can be tapped in the future, and information transfer (through students) will continue.
2. Discipline range. Universities, by their design, incorporate a wide range of disciplines. In innovative approaches to research, these disciplines can be brought together. This discipline mix can be brought about because the talent is in-house, and as a result of program continuity, will remain in-house.
3. Students. Universities involve students in the conduct of research. Students, imbued with the cutting edge of knowledge, are true apprentices to the discipline. Working on master's theses or doctoral dissertations, under supervision, they can apply dedicated time, energy, and intellect to the in-depth solution of a research problem using the available university resources. Dedication to task and freshness of approach often lead to insightful, well-constructed research, while it simultaneously prepares the student, through the learning of methods of problem solving, for entry into the profession.

MEASURES OF RESEARCH SUCCESS

The success of research efforts at institutions can be readily measured. There are traditional academic standards that can be used to evaluate research. In addition, there are new standards evolving, which might, if unchecked, change the nature of inquiry at academic institutions, and not necessarily for the good.

Traditional measures include

- Program output and growth;
- Development of new, utilized methodologies;
- Infusion of new knowledge in program;

- Application of research results by profession with measured results; and
- Prestige of faculty.

New measures include

- Ability to patent, sell, or lease direct products or by-products of work; and
- Dollar value of research support.

A successful research program is one in which real solutions to the problem studied can be observed, milestones of success measured, and positive responses to the work forwarded from outside the institution. Through the stimulation of faculty interest, student interest is increased. Successful research programs act as magnets for students and faculty, and this in turn helps program productivity and sustains success.

Measures of success in transportation are also provided by dissemination and use of the research products. The dissemination is seen not only in textbooks and technical papers, but also in reports of on-line use by transportation agencies.

Institutions change, however. Many institutions now measure success principally in terms of external dollars of research support. Although in one sense this can be considered an incentive, a lessening of true academic research can result from an institution making dollar values of research the primary goal. That this has become an academic way of life has had a dampening effect on transportation research.

Successful research programs stimulate faculty interactions and foster a continuity and growth of institutional transportation activities. In the next section the format and context of research in an academic setting is discussed in more detail.

CONDUCT OF RESEARCH AT A UNIVERSITY

Research organization and management has the following components:

1. Identification of a problem,
2. Organization and management of people and equipment to approach the problem, and
3. Dissemination of research results.

There are a number of organizational approaches to research. These are given in Table 2. Table 3 further delineates the participants in the research process. Although a solitary researcher working on a problem in an office or a laboratory is considered to be the traditional academic approach, it is more likely that a transportation researcher will be part of a faculty-student group or a team. The researcher, however, will contribute a specific area of knowledge. In academic research it is often expected that each member of the team or group will make a significant (and publishable) contribution to the research being conducted. The products of academic research are often technical papers of two forms: papers internal to the project--working papers and interim and final reports and papers for publication in technical journals.

TABLE 2 Methods of Conducting Research in Academic Settings

Type of Research	Approach
1. Single faculty, unsponsored	Faculty member defines problem, addresses to his or her perspective, writes technical papers and reports as part of academic load, or on own time.
2. Single faculty, student support	Faculty, as in item 1, defines problem, has internal or negotiated external support for student(s), graduate or undergraduate, who conduct background research on problem. A variation of this is thesis or dissertation prepared by student under supervision of faculty, and the topic is selected by faculty (student or university is source of student support).
3. Single faculty, sponsored research	A faculty member conducts a research study that he or she proposed to a sponsor in response to a problem delineated by a sponsor, or that is on a negotiated topic. Support is provided by the sponsor for a portion of the faculty member's time, student support, and other essentials of the work. Products of the work (reports, test procedures, equipment, etc.) are often specified, and the time of delivery of the reports is often specified.
4. Multi-faculty sponsored research	Essentially the same as item 3 except additional faculty from one or more academic departments are involved, and the project level of effort is greater.
5. Research centers or institutions	Umbrella organizations for campus-wide transportation programs; centers play many roles. They can provide a large-scale link from the university to the professional world, represent a wide variety of disciplines, and provide the resources for seeding research studies and supporting students.
6. Consortium	Inter-campus groups have the ability to pool, or build on single campus capabilities. This might provide a sponsor formidable groups of faculty who can bring a wide array of talents to bear on a particular problem. Students would benefit by enlarging disciplinary contacts different from their own contacts.

TABLE 2 (continued)

Type of Research	Approach
7. Fellowships, exchange	Academic faculty are sometimes presented unique opportunities to increase their own knowledge through concentrated study in a particular research area. Fellowships that permit devoted study on the faculty's campus, on an exchange campus, or in a federal or private agency are examples of this type of external support.
8. Student fellowships	Some agencies provide opportunities for students to work on research projects either on campus, or at the agency location. These fellowships may also stipulate that a faculty advisor be associated with the project.

TABLE 3 Principal Personna--University-Based Research

Participant	Research Process
1. Faculty member	The university professor is at the heart of campus-based research. The link between the research, acting as principal investigator or faculty associate, or project consultant; defines, or helps define the scope of the research, is responsible for its intellectual content, is responsible for the methods and procedures of the research, and is responsible for the products of research. Further, the professor has the additional responsibility of integrating the knowledge gained in the research into the content of his or her teaching; this is where the growth and dissemination of new ideas really takes place.
2. Student	The student is the first in a line of beneficiaries of the research. By going through all of the steps of the research process, students form habits of problem examination and solutions that will remain with them throughout their careers. The student represents, therefore, not only the professor's thinking, but the next generation of approaches to research and problem solving. Although this may seem an ideal, it is an important concept of academic-based research.

TABLE 3 (continued)

Participant	Research Process
3. Sponsor	The sponsor underwrites research projects through the allocation of resources to the campus where it wants the work to be done. The sponsor can be relatively uninvolved in problem selection (National Science Foundation or a state research board) or can define a problem extensively and fund those it believes provide the best approach. The sponsor has the ability to define the scope of a project, in any instance, through the magnitude of resources applied to the problem. The nature of these resources most often takes the form of a project budget.

There is one other aspect of published research unique to universities--the student master's thesis or doctoral dissertation. These serve a number of purposes. First, they train the student in the methods and rigors of research. Second, they enable the student to focus on a problem in detail, and help the student become a resident expert in a given area. Third, they enable the student, a fledgling professional, to make a contribution to the field, through a well-written treatise. The transportation profession trains and disciplines its future leaders through this process. The more attention paid to the graduate education process, the more rewards will be reaped from it.

Another method of dissemination of research is to present talks and discussions at professional meetings, conferences, technical briefings, seminars, and workshops. This is an excellent method for rapid dissemination of work in progress, recently completed work, or even forums for the initiation of new ideas. Major congresses provide opportunities for cross fertilization of new ideas and approaches, and often serve to inject new directions into research programs and new ideas into academic programs.

It should be noted that in recent years there has been a professional outcry that the academics are monopolizing many of these conferences and meetings, to the dismay of practitioners. Many academics have responded by directing their research, or research products to a more applied outcome. Before I address this issue, which I believe to be one of the most critical in assessing the future directions of academically based transportation research, it is necessary to discuss how research needs are generated and the influence of the sources of research support.

IDENTIFICATION OF RESEARCH NEEDS

The proliferation of transportation journals, conferences, and meetings would convey the appearance of unsatiated research needs in transportation, limitless resources to work on the problems, and growing numbers of academics making transportation a career. Yet we are at a significant crossroad in transportation education. Academic programs and student demand are shrinking, and sponsored research, especially at the federal level, is also shrinking. The problem areas the current generation of tenured (senior) faculty learned and worked on no longer appear to be the critical areas. Where, then, is the audience for the products of our transportation research?

Statement of Needs

Research is driven by the inquiry into what makes things happen. Applied research further asks how can things that behave poorly be made to behave better. Transportation as a discipline is primarily an applied discipline. Those seeking solutions to existing problems far outnumber those asking the more general whys. This masks the strong need to establish valid theoretical approaches to transportation problems, theory that may help deal with the short-term problems as they continually arise. The needs statements that are developed today are more in response to improving our given systems than in questioning future transportation requirements.

Needs statements are generated by

- Institutions and agencies outside academia,
- Faculty members, and
- Students.

The institutions that identify needs include federal agencies, state and local agencies, the National Research Council, and some private organizations, firms, or foundations.

In the areas of highway and public transportation, the U.S. Department of Transportation (DOT) and state agencies have had more influence on the direction of research at universities than any other sources. In the last 5 years, these needs have become very short run and pragmatic. Both federal and state agencies appear to be faced with extensive problems that demand immediate attention, and both appear to have few resources to deal with them.

Needs statements are often turned into research programs. There have been two major dedicated university programs at DOT; the Program of University Research (now in the Office of the Secretary) and the UMTA Program of University Research and Training. Both programs generate needs statements through solicitation from DOT program offices. The needs statements reflect current-year DOT policy needs. Programs officials do not have interplay with outside personnel (including academics) in preparing the statements. The statements are often extremely applied, lend themselves to a narrow problem or project, and have a short period of investigation and interest. This process of needs identification, conducted on a yearly basis, does not lend itself to the development of programs at institutions through continuity of funding, or breadth of approach. A better model of the latter was the earlier UMTA program grants, or the current UMTA centers grants that promote continuity.

The National Cooperative Highway Research Program and the National Cooperative Transit Research Program are also project oriented, and address specific issues that individual states identify. Clearly, these agencies that set major transportation policy assume that academic institutions can be participants in research, yet they abdicate the role of helping formulate and underwrite academic research policy directions.

DOT has, in the past, published national priorities, or agendas for transportation systems. The identification of such agendas, again, should serve as stimuli for research in those problem areas. The current federal position is to delegate the generation of transportation needs statements to the states.

The dilemmas we face today arise, not because we have no sense of need or priority in transportation, but because the setting of major priorities in research is decreasing at the federal level, and the slack is not being taken up rapidly at other levels. University researchers, in the past 5 to 10 years, in all but a few instances have served as reactors--reacting to stated needs and matching talents to formulated programs. These programs, however, had short-term objectives, were extremely applied, and were often narrowly focused.

There are two major points to be gleaned from this. The first is that federal mission-oriented programs have made faculty groups focus on applied programs and develop capabilities to respond to those program needs. Certain universities have developed capabilities in such areas as transit operations, transit maintenance, paratransit, safety, traffic engineering, and rural transit. If universities develop critical skills in transportation programs, that is, groups of faculty who have complimentary skills to deal with the research areas, these skills can be expanded in the area of research or begin to approach other areas of interest. This is the ideal situation, where a research program stimulates growth. In the case of less than critical mass (one or two faculty members), pressures for research support might cause the faculty to shift from area to area. Lack of continuity of research direction or support might hinder mature development in a specific field.

The second point is an emphatically positive point. University researchers have shown not only the ability to respond to federal or state research programs, but they have made significant contributions. Universities have always taken the lead in the development of analytic techniques for transportation system analysis. But they also have developed innovative approaches and solutions to problems such as:

- Services to the elderly and handicapped,
- Stress and strain instrumentation of highway-related structures,
- New standards for highway capacity, and
- Information concerning child safety in automobiles.

In summary, transportation research needs, although often articulated by university researchers, are not always adapted by sponsoring or policy-directed agencies. Transportation system needs and their related research and development agendas are set by federal, state, and local agencies. These agencies are extremely conscious of the scope of the problems they must work with and the limited resources to solve those problems. Hence, in recent years such agendas have become very short term and quite specific. Further, the setting of such agendas has shifted from national policy to state policy. Universities have shown a continuing ability to respond to such programs, but have done so at some costs to program expansion and continuity. Further implications of the sources and levels of support are given in the next section.

SUPPORT OF RESEARCH

University research is supported in two ways: external support, that is, funds from sources external to the university acquired to support specific research, and internal support. Internal support, in its simplest form, is the university support of a faculty member in his or her research work. Such support can take the form of time away from teaching activities for research activities, or it can be internal academic grants to support equipment, computer time, travel, summer support, and student support.

In an active research program, there must be a balance between the two. As an example of the levels of support, a budget is given in Table 4 for a typical research project involving one faculty member (at 20 percent of the academic year, in days per week, and 2 months during the summer).

TABLE 4 Costs of Research Support (dollars)

Cost of Typical Research Projects[a]

Faculty member working 20 percent of academic year, on study 2 months during summer
Graduate students 50 percent academic year, full-time during summer

Salaries and wages
Principal investigator: 20 percent (35,000) + 2 (35,000/9) = 15,000
Graduate assistants: two at $10,000 = 20,000
Secretary: 10 percent (15,000) = 1,500

Fringe benefits 15 percent of salaries and wages = 5,500
Supplies = 1,000
Travel (visits with sponsor) = 1,000
Computer (some cost sharing with university) = 500
Subtotal (direct costs) = 44,500
Indirect costs (65 percent of direct costs) = 29,000
Total = 73,500
Person years = 1.4 per years
Budget = $52,500 per per person year

Graduate student assumed at $10,000 per year (50 percent time academic year, 100 percent summer)
Faculty salary assumed at $35,000 year (academic year) (9 months)

Note: Overhead at 65 percent; fringe benefits at 15 percent.

[a] A faculty member at a research university might spend 50 to 75 percent of his or her time on research activities, some funded, some unfunded. This budget shows the allocation of time to a particular project, but does not account for 100 percent of the faculty member's time.

To conduct a research project of this magnitude, a faculty member might seek support from a number of sources. Often the faculty member will seek external funds from an identified program for all or most of the budget. Quite often a university is asked to cost-share, that is, to provide some of the support for the research. In a university that is research-oriented, such assumptions by the sponsor that a university should cost share are legitimate.

Currently, there are few federal programs targeted to universities by DOT for the support of research. Those that are active and their funding levels are as follows:

- DOT, Program of University Research, Office of the Secretary, $800,000 for minority institutions.
- UMTA, Program of University Research and Training, $2,000,000, of which $1,000,000 is targeted to ongoing centers programs; $200,000 to the Summer Faculty workshop leaving $800,000 available for open competition.
- Maritime Administration, $500,000.

Each of these programs supports research projects for which specific delivered products are required; often final reports are required after 1 year of work.

Examining the implications of these budgets, it can be observed that in a typical budget year, DOT funds $3,300,000 targeted to universities. This amount of funding supports approximately 45 research projects, or 90 graduate students. This is certainly an inadequate base of support from which to provide a steady supply of well-trained future professionals to the disciplines.

Thus, faculty seek other sources. First, they might compete with consulting firms for other federal contract research. Second, they may approach the National Science Foundation (NSF). However, only since 1983 has NSF recognized transportation research as a program area. Some support has been available for civil engineering, or economics and geography-related projects. The entrance of NSF into the funding arena, however, is a significant and primary sign for the rest of the 1980s.

Faculty also look to state agencies for support. Successful partnerships have been forged in Texas and Indiana with state transportation departments and universities, but these close working arrangements are the exception rather than the rule. Too often states conduct in-house research themselves or do not pursue research activities. Rather, they seek answers to highly applied, short-term problems. Agencies are reluctant to contract with universities because of what are stereotypical attitudes toward the ability of professors to visualize and deal with problems as the state agencies define them.

This dichotomy between many state agencies and universities must be resolved if academic research programs are to be revitalized. States will assume a greater role in research as the federal government continues to relinquish that role.

The dichotomy can be generally stated as follows. State officials seeking solutions to urgent problems perceive academics as too theoretical, too slow to respond to problems, and difficult to communicate with. Academics perceive that state officials look for too simplistic answers to complex problems, are unwilling to develop true research applications, and are difficult to communicate with.

The irony of this standoff is that, quite often, the state officials are former students of the programs that they now disdain. This is not a problem without a solution. First, of course, is the need for communication and mutual respect. Second, each of the participants must acknowledge the attributes of the other. State officials are highly pressured to produce visible results in short time periods with limited resources. And they do seek help and innovative ideas. But there must be an attempt to understand their language and the scope of their problems. Academics are cerebral and introspective. They cannot always work in the same time frame or on the same agenda as a consultant, and they are independent. The latter is the key to the strength of academic research. State agencies must realize that just as they are constrained in how they deal with problems, universities are constrained in how they respond.

Universities have a primary obligation to educate their students. Utilization of students is paramount in research projects. In the short and long run this is, consistently, the finest product of university research--a well-educated professional who will mature in his or her work.

Finally, faculty support can come from within the university. Many universities expect their faculty to show the outputs of a scholarly career--usually in the form of publications. Faculty seeking self-support often work on problems of their own interest. Such projects often become the seeds of more grandiose studies that might become funded by external agencies.

Research universities base their success on their graduate programs. At the heart of graduate programs is the ability to support students' activities during their graduate career. Such support requires substantial money. For example, a graduate student working on research might take 2 full years to attain a master's degree. The cost of supporting such a student might be:

Salary	$12,000/yr x 2 =	$24,000
Fringe benefits	5 percent	1,200
Tuition	$ 2,000/yr	4,000
Total		$29,200

Although universities have some funds to offset some of the student costs, they do not have adequate funds to support the number of students necessary to sustain a viable graduate program. Thus faculty is under pressure to obtain support for their research ideas, or to find research support for their program. This in turn forces the faculty to be more responsive to stated needs (rather than negotiate faculty-initiated ideas) and leads to some of the problems raised earlier, notably program context, program continuity, and uncertainty of research direction.

Absence of Support

It is difficult to sustain research and even in-depth academic programs in transportation in the absence of funded support. Students may be ambivalent about their career interests and drift to areas more promising in support. Often students (mistakenly) assume lack of research support implies lack of career opportunities; this has been occurring in graduate transportation programs. Without graduate students to pursue ideas and develop theories and hypotheses, faculty may also wander in their interests. Program dilution occurs. In addition, without faculty and students to contribute to the knowledge of transportation through the literature, programs lose their important dynamics.

Research is the glue that sustains a critical mass in transportation programs. Faculty share the excitement of solving problems with their colleagues; their students, often being classroom learners for 4 years, become real participants and real contributors to the solutions of the problems.

Research support must be considered an investment in

1. Education--the stimulus of and furthering of knowledge in a discipline. Research conducted at institutions is designed and devoted to the advancement of knowledge. Transportation agencies are not designed to educate or advance knowledge, their mission is to underwrite the provision of transportation services. The distinction between universities and transportation agencies must remain clear.

2. Long-term solution of problems. The accumulation of and advancement of knowledge at an institution can be called on, not only to respond to current critical problems, but also to reflect on and anticipate future problems. Further, if continuity of support is assured, these institutions can be called on in the future to deal with problems unforeseen now.

3. Future professionals. Transportation is related to nearly one-quarter of our gross national product (GNP). The organization, operation, and future of our transportation systems are complex, and large numbers of professionals will be needed to serve our transportation needs. Where are they to be educated and trained? Where will today's professionals get additional training? We must provide incentives for academic institutions to develop modern transportation programs. Without making this investment, the costs of our future transportation problems will be much greater than we can imagine.

FUTURE OF RESEARCH

University Approach

The methods of conducting research at a university--a professor or group of faculty working in concert with graduate and undergraduate students--is a continuing part of university life. The product of a university is the advancement of knowledge. Transportation research is not an exception. Transportation is an applied discipline. Housed primarily in schools of engineering, but increasingly housed in schools of management and planning, transportation is primarily professional.

Success for faculty in an academic institution is readily measured by attainment of tenure and promotion from rank to rank. The evaluation for promotions in research-oriented universities centers around scholarly output, the quality and quantity of published work, and the evaluation by peers of the overall content of the work.

Research is the method by which scholarly work is produced. As noted, transportation research is complex and applied. Although financial support for transportation research might provide the vehicle for the conduct of studies, it does not always lend itself to peer acceptance of scholarly research. There must be, at the university level, a filtering of projects so that those that lead to scholarly work can be accepted and those that are more geared to routine testing laboratories are not.

A review of current public agency research agendas shows that, at every level, transportation needs appear to be short range and applied. This does not mean that such research topics are without scholarly content. The opposite is true--a good researcher should, in addressing the problems that have been delineated, derive the more generic or causative components and report on them.

An example of successful approaches to such targeted problems is the measurement of displacement of embankments under stress during construction of highways. From a state highway department, the problem is perceived simply as one of developing a nomograph with soil type, level of stress, and height of embankment. University researchers, over the past 15 years have contributed not only new methods of layered-stress analysis and field instrumentation, based on a range of electronic theories, but also new methods of laboratory investigations and new theories that would help predict soil behavior under a range of conditions. Thus, what begins as a seemingly mundane local problem results in major disciplinary advances that can be applied in a variety of other situations.

Current Trends

Because transportation as a discipline is so problem oriented, the focus of needs continually shifts. Universities, (continuity being one of their strong traits) cannot adapt as quickly to these shifts as needs dictate. University researchers have been spoiled over the past 20 years as transportation problems focused on the development and growth of our national transportation infrastructure. There was a long period to develop highway engineering programs and transportation planning programs, the latter often concerned with the establishment of long-term needs. Many of those needs have been met. The same problems of design and planning studied 10 years ago do not need to be studied today.

What needs have emerged from this 20 years of incredible growth? There will be the highway and transit needs of the next decade, and researchers will begin to adjust to the mix of technical skills to address them. These include all aspects of infrastructure renewal and developing new understandings of the place of public transit in our cities.

The first pressure on academic programs will come from the labor force. The demand for professionals to meet these evolving needs will result in program changes. Those universities with research programs directed to these issues will have the greatest national impact on curriculum changes as research results translate into required professional reading. We are beginning to see some of these changes occur. This evolution, of course, is a slow process. The amounts of federal funding for transportation programs available in the 1960s and 1970s will not be available, or will take different forms. Thus, more initiative rests in academic departments to sustain and underwrite the discipline as new priorities and modes of funding develop.

Future Needs

In an earlier section, I noted that universities had somewhat abdicated their roles in developing long-term transportation research agendas. It is essential that universities serve as more than reactors to the transportation research process. The link of computers to transportation (and the early notion of Dial-A-Bus) at MIT and the introduction of disaggregate demand models at Northwestern are excellent examples of universities taking the initiative and exerting long-term impact on the profession. Tomorrow's transportation needs are not entirely concerned with transit costs and pavement management. They include

- Further impacts of computers and communication technology on transportation,
- Advances in vehicle safety,
- Improved understanding of human factors in transportation,
- New generations of planning and forecasting models, and
- New vehicle energy sources.

Again, these are but examples on a long list. If we are not thinking about and studying these needs in our universities, we do a disservice to the profession. The university, in addition to having an analytic capability, has a historical obligation. Researchers study the past in their discipline in order to make advances; as such they have a perspective that is not duplicated elsewhere. This perspective must be used in delineating and studying the future.

We have built our highways and are using them. The research that helped in that task is now history, and, as such should be taught in history classes. It is time to look ahead to what we must build for the next generations.

Institutional Changes

In addition to program changes, which will occur because of changes in demand on the profession, organizational changes have taken place at universities. Many universities have formed interdepartmental transportation centers or institutions. Further, the federal government has designated centers to carry out specific tasks in transportation. UMTA has designated nine institutions to serve as transit training and research centers. In anticipation of future centers being funded, and as a result of further federal legislation, many groups of universities are forming consortia to combine the diverse talents and disciplines of those universities as well as provide extended opportunity for students to conduct research outside their own institution.

Although universities with existing programs in transportation have been finding new ways to accommodate or attract research, becoming much more entrepreneurial in their approaches, a major thrust has been initiated by the U.S. Department of Transportation to involve minority institutions (the largest segment of which are the historically black colleges and universities) in transportation research and training. With emphasis on proposal preparation, identification of research agendas, and major training workshops, a new peer group is finding its way into the research arena. Nonminority institutions have an obligation to ensure that this development is sustained and fruitful.

CONCLUSIONS AND RECOMMENDATIONS

We are currently involved in major changes in the development and use of our transportation systems in this country. Coincident with these changes are the research programs and academic programs needed to support our transportation systems during the next decades.

Research at universities is unique, must remain that way, and must be supported in its uniqueness. We must not forget that universities are not merely the symbols for the quest for knowledge; they are the workplaces in the quest for knowledge. Universities thrive on ideas, and not every idea is developed with the thought of a payoff.

Somewhere people must be allowed to try and fail, without risk. That is how a large number of paths are narrowed to a few. That is the source of debates about which productive inquiry is based. That is the source of the successes.

Conclusions

The inquiry into university based-transportation research has led to the following conclusions.

1. Transportation research is an integral part of academic programs at many universities and colleges. It is normally conducted by a team consisting of at least one faculty member and one student, often more of both, and often multidisciplinary.

2. Transportation research has a beneficial impact on academic programs. First, it provides new ideas and theories for use in a formal curriculum. Second, it provides both formal and informal training for graduate and undergraduate students in both the demands of their future profession as well as the methods of conducting rigorous inquiry.

3. Transportation research today is shifting from dealing with problems concerning the building and development of our infrastructure to problems of managing, operating, and extending the life of our infrastructure.

4. Transportation research at universities should be dealing with longer term needs of our population, including the impacts of rapidly changing demographics, a shifting economy, and the growing role of computers and communication in the workplace. It is not doing so now, although it is clear these influences will begin to have a major impact on our transportation systems within this decade.

5. Academic transportation research has been influenced by short-run, pragmatically stated national, state, and local needs. Academic research has been responsive to and creative concerning these articulated needs, and the profession has visible evidence of these successes. Understanding the costs and benefits of deregulation, utilizing new methods of planning analysis, and integrating microcomputers into all aspects of transportation are but a few of the many university success stories.

6. Academic research responds to its own reward structure. Promotion and tenure are often based on the quality and quantity of publications and the ability to obtain sponsored research. In recent years, however, the pressure to obtain sponsored research, per se, has begun to outweigh the academic merit of the research. Pressures to obtain research support, as such external support is dwindling, has led to some program disruption, some loss of students, and some loss of faculty (or shifting of faculty to more well-off institutions).

In one sense this restructuring is a healthy process. Institutions that cling to older models of transportation analysis might need some restructuring. In addition, the development of strong new programs to deal with evolving issues at institutions with relatively new transportation programs (many in the south and southwest, and some new programs at minority institutions) will lead to new program development by transference throughout the country.

7. What is lacking at traditionally strong transportation institutions is the development of new research programs that will address longer term, innovative transportation agendas. Such programs, because they are pathfinding, might need to be self supporting. In this era of pragmatically based research support, few external dollars are available for general exploration. The problems of developing such programs come, not from the lack of interest by faculty and students, but from the lack of encouragement by the institutions themselves. Transportation research must again capture the uniqueness of inquiry that our academic institutions have and can provide.

RECOMMENDATIONS

The following recommendations are made on the basis of the foregoing conclusions:

1. Academic transportation researchers need to be more introspective about the future of our transportation systems. We must gain some sense of the likely and fruitful directions in which our systems are evolving (or will be developed at) and conduct research and disseminate the results. Academic researchers must take a bolder hand in shaping transportation policy rather than reacting to it. This can be accomplished through a number of steps:

- University-sponsored conferences and workshops on future transportation needs.
- University allocations to support new-direction research. Such allocations might come from overhead generated from ongoing research programs.
- University research presence on boards and commissions.

2. Research boards (with strong academic research components) should be established to set transportation priorities, publish such priorities, and generate discussion on these priorities. Such boards do not need official imprimateur. They can arise from committees of TRB, or ASCE, or be ad-hoc committees structured by a group of faculty researchers and practitioners. Graduate students would serve on the boards or committees of the boards. They are the continuing links between academia and practice.
3. University researchers must become more vocal advocates of their profession. Their products--new ideas, well-trained professionals, and unbiased research studies have not been receiving the accolades they deserve. Perhaps the TRB Education Committee can take the lead in developing and disseminating a booklet on academically based university research.

Academically based transportation research has always demonstrated that it can be a good investment--a good investment to the sponsor, to the faculty, and to the students. By reemphasizing the university tradition of extending the base of our knowledge, we can be sure that the rewards to be reaped continuously from that investment will increase.

Education and Training Needs of Women in Transportation

Lillian C. Liburdi

When viewed from the financial or economic perspective, transportation is one of the five major industries leading the U.S. national economy. The transportation industry is comprised of a vast array of businesses--from aerospace manufacturing firms to urban transit--including the host of traditional businesses dedicated to achieving the movement of people and goods.

In surveying the types of jobs or people required to carry out business in the transportation industry, it is likely that any and every discipline, educational background, and career history possible can be found. Most likely the range would be comparable to that in any other major sector of the economy. But that probable range is not the real concern even though it offers hope to anyone interested in a career in transportation. The interest here is whether, knowing the breadth of talent and the diversity of skills, background, education, and experience that exists among those serving the transportation industry, women as participants in the industry are achieving success in ways and at levels comparable to those achieved by male practitioners. And further, whether female industry practitioners have educational, training, or development backgrounds and needs that are similar to, or different from, those of their male counterparts. Beyond the examination of differences, if any, that may exist, we are also interested in learning the number of female practitioners and what steps, if any are necessary, should be taken to assure the attractiveness of transportation as a career field for women.

In addressing these questions, we begin with a basic premise: In the competitive, deregulated, economic environment the transportation industry faces today, with the international pressures to continue achieving the type of growth experienced in the past, businesses must capitalize strategically on all of the resources at their disposal. The most critical, of course, is human capital.

It is apparent that the shifting demographics of the United States, that is, an aging population, low birth rate, population shifts to the Sunbelt; and increased educational and per capita income levels, are affecting the United States dramatically and that the transportation industry is experiencing the impacts of these changes. For example, in the transit industry, "because of their age, managers will need replacement in greater numbers, which will make the next five years critical for the industry" (1). ". . . While in the railroad industry during the 1980s, it is estimated that one-half of the railroad industry's current workforce and about two-thirds of top and middle management personnel will retire" (2). Similar experience appears to exist in the highway and aviation industries. Therefore, as these opportunities arise, it is important to consider and find answers to the questions set forth.

In beginning efforts to address these questions, literature searches and discussions with educators and transportation professionals demonstrated that although some aspects of the role of women practitioners are being examined, for the most part, these studies focus on preparing women returning to the labor force for a career in transportation; how to attract women to undergraduate programs to train them in the sciences and technologies pertinent to transportation careers; the success that has been achieved in employment by the U.S. Department of Transportation through special training programs to prepare women and minorities for transportation careers; and similar important and useful data. No major effort appears to have been initiated to help assess the skills that contribute to a successful transportation career or when technical versus managerial competence is critical to success. Further, no real analysis of successful male transportation managers' backgrounds has been undertaken to generate clues about career paths or skills and interest combinations useful for role modeling and as a foundation for career planning for women in transportation.

The closest effort to this assessment approach is the program initiated by the National Research Council Commission on Behavioral and Social Sciences and Education. During the Women in Science and Engineering planning meeting in September 1983, the results of a pool to determine activities for a new committee on women in science and engineering was reviewed. The responses received suggested studies of career choice and development patterns of men and women in science and engineering. The results of these studies could be useful to precollege and college-level educators, employers and support networks, and studies of career and family conflicts to assess not only which factors contribute to success stories, but also how many women dropped out or made alternate career plans, when, and why. Also, studies were recommended to focus on the development of better, more objective data on men and women in science and engineering careers. Additional studies were recommended to assess residual barriers for women in science resulting from gender bias in the organization, values, goals, and methodology of science as well as studies to assess policies and procedures used by institutions successful in reducing barriers to the participation of women.

Based on the poll results and the commission's assessment of the opportunity to accomplish change, the planning committee suggested that the National Research Council prepare a status report on women in science and engineering, initiate information-sharing activities, and develop a research agenda.

Absent this kind of approach, which may be appropriate for consideration by the participants at this special conference on transportation education and training, it appeared reasonable to turn to two familiar sources: the report by the American Public Transit Association's (APTA) Women in Transit Task Force prepared in 1980 (3), and the Women's Transportation Seminar (WTS) 1983 Educational Survey results (unpublished), as well as the results of focus group discussions conducted among WTS members, primarily female transportation professionals, in New York, Philadelphia, and Washington in 1983.

The 1980 APTA Task Force report, which will be updated in 1985 through a survey of women in public transit jobs, was conducted by Michigan State University at the request of the APTA Women in Transit Committee and provided data that are striking when compared to the WTS survey results pertaining to female transportation professionals in various transportation modes. The APTA report was prepared as a means of documenting the underutilization of women in transit and to stimulate an effort within the industry to structure an overall approach to the recruitment, hiring, and training of women.

The report contrasted census data with the data received through a survey of

31 transit systems throughout the United States, as well as through questionnaires directed to approximately 100 women employed in transit. The report indicated that in 1970, 18 percent of the national work force was represented by women in full-time positions, 11 percent worked part time, and 71 percent were unemployed. By 1980, 35 percent of the national work force was represented by women in full-time positions, 12 percent part time, and 52 percent unemployed. Parenthetically, it is of interest to note that a newly released report (4) by the Consumer Research Center Conference Board indicates that women now (1984) comprise 45 percent of all workers. In 1980 women represented 13.2 percent of the transit work force and were employed predominantly (59.9 percent) in the office-clerical category (Table 1). Employment of women in large transit systems, those employing more than 3,000 people, was very low, regardless of geographic area, whereas large, all-bus systems appeared to show average percentages of female employment. Medium and smaller systems showed a wide range of female employment rates.

The 100 women surveyed by the APTA Task Force were asked to answer questions about career goals, education, professional affiliations, and their perceptions of the transit industry. Forty-six women replied. Based on these replies, 70 percent believed that they faced real or perceived barriers to employment, training, and career mobility because of their sex. The respondents cited barriers such as stereotypical ideas and moods, negative attitudes toward women in top management positions, the inability of women to easily relocate, and educational disparities. The women cited one result, that women managers are frequently confined to nonoperational, administrative positions such as personnel, marketing, community services, and the like, that continue to perpetuate the status quo.

TABLE 1 Breakdown of Percentage of Females in Transit Work Force and in Total Work Force

Work Force Category	Percent Female in Transit Work Force	Percent Female in Total Work Force	Deficiency in Transit Work Force to Total Work Force
Craftsmen	1.4	6.0	76.7
Office/clerical	59.9	79.8	24.9
Officials/managers	7.0	25.8	72.9
Operators/service	9.8	44.7	78.1
Professionals	22.0	28.2	22.0
Technicians	15.9	28.2	43.6
Total	13.2	42.1	68.6

Of the 46 women who replied, the majority was between 30 and 40 years old. Four percent of the women who replied had a high school education only, 20 percent had some college, 13 percent held undergraduate degrees, and 41.3 percent held graduate degrees. Every one of the respondents in the 30 to 40 age group had more than a high school education. Of those 40 and older, 9.1 percent had a high school education, as opposed to 6.2 percent for those women under 30. The 40 and older group had the highest percentage of college experience without receiving a degree (46 percent), whereas 66.7 percent of the 30 to 40 age group had graduate degrees. The majority of degrees held was obtained in business administration, public administration, and planning.

In a separate survey of female transit board members, 44 responded of 100 surveyed. Their replies led the APTA Committee to conclude that the board members were more assertive, self reliant, and manifested greater aspirations for themselves as board members than women employed in transit. Both surveys indicated that women desire more exposure to all facets of transit and that women employed in transit placed great emphasis on the availability of educational and career development programs within the industry.

With regard to training and career development for women, the APTA Task Force stated that the industry must not only assure that programs are available but that they have maximum impact on the career development and aspirations of women.

The WTS survey undertaken in fall 1983 was intended to develop a WTS membership profile and to recommend strategies for WTS to pursue to improve education and training opportunities for its members.

The survey was sent to approximately 1,300 members of the 12 then extant WTS chapters. The data that follow are taken from the survey report prepared by the WTS Education Committee. A total of 236 replies were received and reflect a wide range of jobs within the industry. Sixty-eight percent of the respondents were employed by government or public agencies, with more than 60 percent involved in passenger transport; 11.4 percent of the respondents were involved in operations, and many (25 percent) indicated their jobs had multiple responsibilities.

The majority of the respondents was between 25 and 36 years old and had an average of 6.9 years of experience. Five percent of WTS members responding were men; 10 percent were minorities. Twenty percent had extremely responsible positions as judged by their titles and salaries; 12.2 percent earned more than $50,000 per year.

Some respondents (22.5 percent) indicated that their education was geared toward a career in transportation, yet only 12 percent had a transportation major in college or graduate school. Of the 236 responding, 59 percent had master's or other graduate degrees; 81 percent of those who indicated their education had been geared toward a career in transportation had graduate degrees. Because survey respondents were quite willing to convey their thoughts in reply to the attitudinal questions, the following material from the survey is excerpted from the WTS report.

Members were asked to rank the significance of education in their background and as a factor important for the success of other transportation executives. To help identify differences in attitudes, the sample was broken down further, highlighting those members with an education specifically oriented toward a career in transportation and those members with high salaries (higher than $50,000 annually). WTS members whose education was geared toward transportation might be expected to consider education as important for success.

The following table gives the percentage of respondents in each group who ranked education as the first or second most important factor in questions pertaining to education.

	As Important for Self (%)	As Important for Other Transportation Executives (%)
Total sample (N = 236)	47	17
Transportation educated (N = 52)	69	19
High earners (N = 26)	46	8

Interestingly, respondents in all three groups perceived education as considerably more significant for themselves than for other transportation executives. This may be attributed to an interpretation of the question--that education is a significant factor in an individual's personal development but not necessarily significant in terms of professional success.

As expected, members with an education specifically oriented toward a career in transportation considered education more important than the total sample: 69 percent considered it either the first or second most important factor in their own backgrounds, whereas only 47 percent of the total sample ranked it that highly.

To assess whether other differences between the transportation-educated group and the total sample might account for this difference, the groups were compared and it was found that the transportation-educated group mirrored the total membership on a number of key descriptors. The average years of service was 7.4, compared with 6.9 years in the total sample--somewhat surprising, because it might have been speculated that because transportation education is a new and expanding field, the transportation-educated members would probably have fewer years of experience. This proved not to be the case. However, 81 percent of the transportation-educated had advanced degrees, compared with 59 percent of the total sample.

Similar to the total sample, roughly 30 percent of this subgroup is comprised of people with the following words in their title: director, chief, manager, or commissioner. Also, similar to the total sample, the transportation-educated are mainly involved in passenger transport: 58 percent deal with passengers, 25 percent deal with goods, 12 percent deal with both, and 5 percent did not respond to the question.

The transportation-educated were not significantly more involved than the total sample in line operations, operations management, or the technical and engineering areas. Eight respondents, or 16 percent, listed these areas as their primary responsibility as opposed to 14 percent of the overall sample.

Also, having an education in transportation did not significantly improve the job satisfaction of the respondents; 11, or 21 percent, of the transportation-educated were dissatisfied, compared with 57, or 24.5 percent of the total sample.

Few members of the high-earning group were dissatisfied with their jobs; 3 of the 26 respondents in this group, or 11 percent, indicated that they were dissatisfied with their career progress to date. This is understandable because high earners generally have been successful in their careers. They also have more years of service than the average respondent--13.5 years, compared to 6.9 years for the average respondent. Like the transportation-educated group, the high earners have a higher percentage of advanced degrees (81 percent) than the total sample (59 percent).

What do the high earners consider significant in their background as opposed to those factors that are important for other transportation executives? The data in the following table indicate the percentage of respondents who listed experience, education, and contacts as the first or second most important factor.

	For Self (%)	For Others (%)
Experience/performance	85	68
Education	46	8
Personal contacts	50	50

Although considering education significant for themselves, the high earners did not perceive it as significant for other executives. However, this group considered personal contacts very important for themselves as well as for other transportation executives. This differs greatly from the transportation-educated group; only 19 percent of the respondents ranked this factor first or second for themselves, and 40 percent ranked it first or second for other transportation executives.

Training courses did not emerge as a significant factor in the background of respondents. Of all respondents, 194, or 82 percent, indicated they had taken training courses during their career.

To focus more closely on how training courses may have contributed, the Education Committee examined specifically those who responded positively to the question: "Were there specific skills or training you needed to acquire after entering the industry?" A total of 120 respondents, or nearly 51 percent, indicated that there were specific skills they needed, and 88 percent of this group indicated they had taken training courses. The skills most often identified as needed were management, transportation-operations, and computer skills; the three accounted for more than one-half, or about 56 percent. Other areas identified included technical-analytic, engineering, federal budget-legislative process, negotiating, public relations-marketing, advanced degrees, law, real estate, and financial skills or knowledge.

Among those who indicated a need to acquire additional skills after entering the transportation industry, training courses did not appear to be an important aspect of their background. In response to a question that required ranking of factors with respect to importance in the respondent's professional background, only two respondents ranked training as first, and 19 ranked training as second, or only 18 percent rated training highly. Alternatively, 24 did not include training in their ratings at all, and another 20 ranked training as fifth or least important, an amount representing nearly 37 percent, which indicated that training is an unimportant element in their background.

Among the group of respondents who had indicated a need to acquire additional skills and who had taken training courses during their career, about 45 percent believed managerial and supervisory courses were most helpful in their career, 33 percent indicated technical courses were most helpful, 13 percent indicated transportation courses were most important, and 6 percent indicated none of those training courses helped advance their career.

Many of the comments made at the round table focus group discussions conducted in the three WTS chapters in 1983 before the education survey was undertaken served as both a predictor of the survey results and an opportunity to focus on some of the questions raised at the beginning of this paper. For example, at the Washington Chapter discussion, examples of career paths led participants to question how transportation management opportunities and decisions stack up against those in other industries and professions. Some specific questions the membership wanted to examine were: How many people working in a specific industry work in a job area unrelated to their academic training? Does the transportation employer seek a transportation degree? If so, why? Does the degree specifically relate to job performance and success? Or is the requirement a means to legally discriminate?

Another focus of the discussions at each of the chapter sessions was whether degree holders, regardless of major, possessed basic job skills, such as communication skills; industry-specific skills such as knowledge of public utility, railroad, aviation, or transit businesses; or functional skills in managerial, legal, financial, and technical disciplines. The sense developed by the discussants was that at the entry level, an employer looks for basic job skills and evidence that the individual can and will progress beyond those skills; that industry skills, the history and culture of the business, may be and are learned on the job; and that functional skills are derived from both the formal educational process and on-the-job learning and training.

However, throughout the discussions, it was obvious that many of the participants expressed beliefs and opinions similar to those expressed by the women transit professionals surveyed 3 years earlier. In both, participants indicated that self-confidence-building activities were a key to success whether they were chances at the start of a career or job to "show what they could do" or challenges by mentors, role models, recognition for good or superior work, or the simple encouragement to try. Knowledge, basic and substantive, was viewed as important to success in a transportation career. Yet, many women believed they had been denied or deprived of opportunities to learn on the job formally or informally. Networking, or the development of personal contacts to offer support, such as mentoring or role models, appears to be important. Yet, most organizations do not encourage these concepts. Finally, many women indicated that even though they believed they had the requisite training, education, skill level, and ability to perform higher level jobs, they missed out because they frequently were not offered the opportunity to compete based on job qualification requirements or their lack of stature in their organization.

If we truly value human capital and intend to utilize all of our resources for the betterment of our profession and our society, then it appears reasonable to examine why women appear not to be achieving as much and as successfully as their male counterparts. The following initiatives should be considered:

1. Conduct a more comprehensive examination of the education and career paths of transportation and nontransportation industry executives to determine factors of success;
2. Determine whether specific educational backgrounds are more likely to lead to success;
3. Determine the number of women in the various transportation industries and the kinds of positions they hold;
4. Determine why women continue to be underrepresented in managerial roles in transportation businesses;
5. Identify barriers to career advancement for women;
6. Evaluate the support structure for women, including mentoring and role models;
7. Determine feedback methods and opportunities for promotion and growth, including on-the-job and off-site training, to learn whether there are differences in the process for men and women and, if so, why.

Further, it is essential that there be a concentrated effort focusing on academic institutions at the secondary, undergraduate, and graduate levels. This focus should encourage the development of approaches that would lead to the understanding that careers in technological fields such as transportation are acceptable and appropriate for females. Additionally, universities were viewed by both the American Public Transit Association and the Women's Transportation Seminar survey respondents as too removed from the real world to be meaningful in helping them to prepare for careers. This suggests that as career path data are developed along with a sense of the value played by transportation-specific training and education in a successful career, university and secondary education institution programs should be evaluated to assess how they can be made more relevant. Some respondents to the WTS survey suggested greater availability of internships and closer relationships between academia and industry.

A much more detailed educational assessment agenda similar to that developed for the Women in Science and Engineering Study (5) should be developed for the transportation industry. In addition, a review of institutional changes in the transportation community with a particular focus on governmental entities, because they appear to employ a sizable number of the women in transportation, exclusive of those in airline operations, should be initiated. Again, the topics outlined by the Women in Science and Engineering Planning Committee appear to be a reasonable point of departure.

Our efforts should not be taken lightly. These steps should be viewed as an investment in the future and as one more effort we can use to achieve greater growth and stability for our people and businesses.

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Transportation Careers for Minorities

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Transportation is a major tool in determining the order of our society. It touches every phase and facet of our existence. The growth of our nation can directly be attributed to the growth and development of transportation systems. These systems provide for the movement of our products and services and the movement of people, in addition to supporting our communication network. Minorities have played a major role in the development of transportation systems as users as well as employees of the systems. In speaking of the contributions of blacks as employees and as users of the transportation system, Gerard Anderson states: "They drove carriages during slavery . . . built and repaired railroads . . . navigated ships . . . invented a self lubrication device for train steam engines and the first traffic light . . . made the beds, and cooked and served meals on transportation carriers (1). Blacks and other low-income residents have long been the major users of mass transportation services, not as an alternative but as the only means of transportation.

Although minorities have made contributions and have been employees in the transportation industry, career opportunities have been primarily at the entry or low level of the career ladder, and opportunities for professionals have been limited in all modes: motor, rail, air, water, mass transit, and pipelines.

Career opportunities in transportation exist within all modes (air, water, rail, pipelines, and mass transit); with regulatory agencies at federal, state, and local levels; and with logistics, materials management, physical distribution, and traffic departments of private industry.

Participation of minorities in programs in general, as well as in the transportation industry, has been directly related to the civil rights movement. As minorities demanded fair and equitable treatment, questions began to arise about discriminatory practices that had, in the past, been taken for granted. The results have been passage of laws and Executive Orders on nondiscrimination in employment and education, equal pay for equal work, and the more recent White House Initiative on Historically Black Colleges. As a result of these efforts, a number of specialized programs have been developed to enlarge the pool of transportation expertise.

"Time is the greatest inventor," wrote Sir Frances Bacon. The time has come for minorities to seek their rightful place among professionals in the transportation industry; progress has not kept pace with the degree of quality and training of these talented and committed individuals. Minorities can and should occupy more professional positions within the transportation industry.

EMPLOYMENT TRENDS IN THE DECADE OF THE 1990s

By 1990 the civilian labor force is expected to be 125 million, an increase of 18 million from 1980. A pronounced shift is expected in the age structure of the labor force; the number of 25 to 54 years olds in the labor force is expected to grow faster than the total labor force. The black civilian labor force is expected to be 14 million, an increase of 4 million from 1980.

During the 1982-1995 period, the number of women and minorities in the labor force are projected to grow faster than the overall labor force. The data in the following table indicate the projected labor force growth and growth for blacks and black and other minorities (2).

	1982-1990	1990-1995
Total	1.6	1.0
Women	2.3	1.4
Black and other minorities	2.6	2.0
Blacks	2.3	1.8

The black and other groups should account for slightly more than 21 percent of the additions to the labor force during 1982-1990. The black labor force is projected to grow at almost twice the white rate, which reflects the younger age structure of the black population (2). Career opportunities for minority groups are increasing in all areas as the labor force reflects growth over the next few years.

PAST EMPLOYMENT AND FUTURE OPPORTUNITIES IN TRANSPORTATION

The number of individuals in the transportation industry is expected to increase by 657,000 between 1970 and 1990 with the largest increase in trucking and warehousing (481,000) (3). The percent distribution in transportation by occupation shows that the greatest percent of increase from 1970-1990 is the managerial, official proprietor occupation (+3.22) and in transport equipment operatives (+4.20) (3).

The U.S. Department of Labor classifies transportation firms and agencies into six different industries:

1. Local and suburban transit and interurban highway passenger transportation,
2. Motor freight transportation and warehousing,
3. Water transportation,
4. Air transportation,
5. Pipelines, and
6. Transportation services.

A list of occupational groups for these industries is given in Table 1. For these industries, managers and officers were the third largest occupational group in 1979. At that time there were 196,000 managers and officers for a total 8 percent of transportation employment. The largest occupation group, as expected, was operating, maintenance, and related occupations (61 percent of total) followed by clerical workers (19 percent of total) (4). Although they are not the largest group, the size of the managers and officers group provides numerous opportunities in all transport industries. The data in Table 1 also show that for managers and officers, the industry reporting the largest employment was motor freight transportation, which employs more than 47 percent of all managers and officers. The second and third largest employers were transportation services (15.5 percent) and air transportation (13.5 percent). Local and suburban transit and passenger transportation were the fifth largest with slightly less than 7 percent (5).

TABLE 1 Percent Distribution of Employment in Major Occupational Groups by Transportation Industry in 1979 (5)

Industry	Total	Managers and Officers	Professional Workers	Technical Workers	Service Workers	Operating Maintenance, Construction, Repair, Material Handling and Power Plant Workers	Clerical Workers	Sales Workers
Total	2,467,290	195,960	81,560	69,740	100,280	1,501,930	477,640	40,180
Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Local and suburban transit and interurban highway passenger transportation	10.64	6.90	1.80	10.58	4.77	13.67	6.12	2.36
Motor freight transportation and warehousing	54.80	47.27	13.34	1.78	13.51	66.55	44.38	54.98
Water transportation	8.41	13.47	6.52	3.14	9.01	9.17	4.97	7.94
Air transportation	17.99	15.02	17.14	81.75	67.73	7.88	31.80	13.24
Pipelines, except natural gas	0.82	0.90	2.43	1.98	0.01	0.88	0.41	—
Transportation services	7.34	16.44	58.77	0.77	4.97	1.85	12.32	21.48

The outlook for all sectors of transportation management is excellent. In allied professions, U.S. Department of Labor projections are at or above the growth of employment overall. One indicator of the job market in this area is the annual earnings for different occupations. Two industries were examined. First, urban and regional planning (allied with transit and passenger transportation) were examined. Most recent figures (for 1980) showed entry-level positions earning a median of $13,800 with an overall median of $24,000 and maximum potential of $32,000. This was contrasted with purchasing agents (allied with freight transportation and warehousing). In the same year that entry positions were drawing a median of $16,200, managers were earning a median of $30,600 with a potential in excess of $50,000 for materials managers (6).

The current salary picture for physical distribution managers is even better. According to the National Council of Physical Distribution Management, current entry-level positions pay as high as $25,000, and top-level physical distribution managers earn between $50,000 and $85,000 depending on the size of the firm.

PAST EMPLOYMENT AND FUTURE OPPORTUNITIES FOR MINORITIES

Statistics were not available on race of employees for the transportation sector but were reported for all industries together. Although approximately 72 percent of all managerial administrative positions were held by white men, only 3 percent were held by blacks even though they comprise 9 percent of the work force. Clearly blacks are underrepresented in managerial and administrative positions (4). Although these figures represent an approximate 20 percent increase in participation by minorities over the past decade, they still emphasize the well-known fact that minorities are underrepresented in managerial positions. Personal anecdotal experience indicates that this underrepresentation is even more pronounced throughout the transportation industry.

There is a projected increase in employment and the employment for blacks is projected to be twice that of other groups. A great opportunity exists for young blacks to work in a strong and growing industry and to be a part of the decision-making process that affects the lives of all Americans. Projections show the strongest areas of need in the manager and officer occupations.

This leads to the conclusion that good potential exists for graduates throughout the transportation industry. However, with the greatest number of positions in motor freight and higher salaries in physical distribution management, the greatest potential for employment appears to be in areas related to freight transportation. This demand has increased in recent years as a result of deregulation of the motor freight industry and the increased cost of fuel. Specifically, physical distribution managers have been elevated in importance in production industries. This implies that academic programs for minorities must include programs in carrier and physical distribution management.

The transportation industry also provides career opportunities for blacks and minorities who desire to become entrepreneurs with specialties in providing goods and services to the industry--such as technical services, including marketing, planning, and engineering; and operational services, including catering, maintenance, and construction. This entrepreneurial role can be enhanced through strong Minority Business Enterprise Programs.

ROLE OF THE UNIVERSITY

There are three general employment categories for which university training has been provided. They are transportation planning, carrier and physical distribution management, and transportation engineering.

Transportation planning programs train students for careers in a field that includes both the traditional role of capital planning and forecasting, as well as the newly defined role of urban transit broker. All of this is in an era of limited financial resources. Most job vacancies appear to be in the newer broker or coordinator area both in urban and rural settings, although for minority students there are still good opportunities in forecasting and related quantitative areas. Many university programs, however, still emphasize the traditional role of the planner despite these changes.

University programs that prepare students in carrier and physical distribution management are preparing them for positions with freight transportation firms or as traffic managers. Physical distribution management involves the following areas: physical distribution planning, physical distribution management, traffic or transportation management, warehouse operations or management, material handling operations, packaging, customer service and order entry, inventory planning and control activities, management information system planning or control, purchasing, production, marketing or sales activities, general management, education, training or teaching, internal consulting and corporate research, and finance and accounting.

One effect of deregulation, however, is that some regulatory agencies are being phased out or deemphasized, which requires fewer people to be familiar with rules of practice. Nevertheless, there is still a shortage of trained physical distribution managers. The salaries of graduates in physical distribution management are substantially higher than salaries in the public sector. Academic programs for minorities reflect these changes in the industry.

Transportation engineering programs train students to design transportation facilities. To the extent that the emphasis in facility construction has switched from new construction to maintenance of existing facilities, the need for new personnel in this area will be limited in the future. The engineering curriculum must reflect this emphasis on maintenance.

Finally, a new role for universities in the transit industry is emerging. This role is to cooperatively provide in-service training not only for management personnel, but also for nonmanagement employees. For example, universities are developing programs to help train drivers to operate vehicles more efficiently. Other in-service examples includes classes and seminars for managers in innovative approaches to service provision, computer technology, financing, accounting, management, and planning.

One example of a training program is the transit management apprentice program at North Carolina A&T State University, which provides 1 year of full-time training for new graduates of the university's transportation program. Students are employed at a local transit agency, and funds are provided by the North Carolina Department of Transportation. Upon completion of the program, apprentices are assisted by the state department of transportation, the university, and the agency in finding permanent positions in mid-level management with transit agencies in North Carolina.

The university that can provide a full set of training programs will find that these programs both complement and contribute to each other.

TRANSPORTATION OPPORTUNITIES AT HISTORICALLY BLACK COLLEGES

Historically black colleges (HBCs) enroll more than 60 percent of all black students. "These institutions provide points of access and often offer better odds for retention and attainment for blacks than are evident in other institutions" (7).

Black colleges have been involved in transportation since the early 1970s. The earliest efforts to increase the involvement of the historically black colleges in U.S. Department of Transportation programs were initiated in 1969-1970 by the Urban Mass Transportation Administration (UMTA). UMTA's University Research and Training Program was authorized in Section 11 of the Urban Mass Transportation Act of 1964. Visits by UMTA officials and UMTA-funded consultants to HBCs resulted in proposals for grants under the program. Three HBCs, North Carolina A&T State University, Atlanta University, and Southern University were each awarded $150,000 grants for the 1970-1971 academic year. In subsequent years UMTA has continued to make awards to HBCs.

Government involvement with HBCs continues today. In 1981 President Reagan signed Executive Order 12320 mandating that government departments and agencies "help to significantly increase the capabilities of historically black colleges." The Secretary, U.S. Department of Transportation directed that "HBCs should be afforded equitable consideration. Special efforts should be made to identify and utilize the areas of expertise which these institutions possess. Each administration should consider establishing developmental programs for faculty and curriculum at these institutions to ensure an ongoing pool of minority transportation researchers."

Transportation Centers for Excellence

In 1982 UMTA approved two historically black colleges as Transportation Centers for Excellence under Section 6 of the UMTA Act of 1964--Florida A&M University and Texas Southern University. Specifically, these centers will focus on short courses, certificate programs, development of operations, management skills, and mid-level management training. Emphasis is also placed on research directed at current transit problems and technical assistance to transit operators in problematic areas.

Academic Degree Programs

Few historically black colleges have full-fledged academic programs in transportation. Several public and private institutions have transportation curricula in the developmental stages. Three undergraduate degree programs have been identified at black colleges--North Carolina A&T State University, Virginia State College, and Florida Memorial College in Miami, Florida. Three HBCs have developed masters' degree programs in transportation--North Carolina A&T State University, Morgan State University, and Texas Southern University. Concentration in these degree programs lead to career development in transportation planning and management with emphasis on mass transit planning, management, urban planning, public policy, transportation forecasting, research, and technical writing. The degree program at North Carolina A&T State University, however, is located in the School of Business and Economics. This program trains carrier and physical distribution managers and is accredited by the American Assembly of Collegiate Schools of Business. Examples of similar programs at major universities are Indiana University and Pennsylvania State University.

Because of government initiatives during the past one and one-half decades, academic programs at minority campuses tend to emphasize, perhaps overemphasize, public-sector training. This is underscored by the placement experiences of recent graduates of North Carolina A&T University. At the undergraduate level, graduates who accepted positions in freight transportation averaged approximately twice the beginning salary of those in public transportation ($25,000 for freight and $13,000 for public transit).

The job market alone cannot be the only influence on the establishment of academic programs. There are two underlying characteristics of most students at minority campuses:

1. A desire to complete an academic program that has a track record of successful employment placements; and
2. A need for a structural program that can reinforce basics at the same time that new, specialized material is presented.

The first point addresses the relationship of the job market to the academic program discussed previously. The second point, however, addresses the content of the academic program itself. For example, a curriculum that assumes advanced mathematical skills for all students, such as an engineering curriculum, will necessarily exclude the majority of students who have average skills in mathematics. Similar observations can be made about programs in the arts.

Business programs, however, require a general competency in a wide range of skills. This competency is typically possessed by many students and, along with the marketability of graduates, accounts for the popularity of business programs at many campuses. It is, therefore, suggested that transportation programs for minorities be located in a school of business and emphasize carrier and physical distribution management.

The accrediting agency for such programs is the American Assembly of Collegiate Schools of Business (AACSB) which, in its accreditation standards, provides for a balance of nonbusiness and business-oriented courses. The AACSB also provides for a common body of knowledge that consists of requirements in several areas of business including quantitative methods, organization and personnel management, policy, and a balance of specialized courses (8). Thus, a business curriculum may emphasize transportation by adopting specialized courses that either contain the common body of knowledge or that are additional courses that can be substituted for more general required courses in business and still meet AACSB standards. This approach has been taken at North Carolina A&T University and to date has been quite successful.

In contrast to the business-centered curriculum, many schools offer a multidisciplinary approach, drawing on courses and faculty from different departments and schools. The primary examples of this are curricula at Northwestern University and the Massachusetts Institute of Technology.

Among the HBCs, Morgan State University has adopted a multidisciplinary approach. Students are provided a required core of courses and then are provided options to specialize in either planning or management (Master of Science in Transportation). Neither specialization includes the entire set of elements prescribed by the AACSB in the common body of knowledge for business. However, this approach offers more flexibility and accommodates specialization at an earlier stage.

Comparing the two approaches, the advantages and disadvantages of each are complementary. The business curriculum requires more business-oriented prerequisites and a greater amount of time allocated to general business content. This has the advantage of providing the student greater strength in an administrative background and, subsequently, in the transportation management job market. The disadvantage is that the business core requirements and prerequisites will discourage nonbusiness majors. On the other hand, the multidisciplinary approach provides specialized transportation courses from the outset and has the obvious advantage of attracting an interdisciplinary student body. The disadvantage of this approach is that the administrative and general academic background of the students is inconsistent, which can affect course content and make students less competitive for transportation management positions when they graduate.

In summary, two strategies have emerged by which minority transportation professionals can be trained. These strategies parallel those at nonminority institutions. Although recognition of an accredited business program appears to fit the needs of many minority students, each school must develop its own curriculum that best fits local conditions. Only time will confirm the relative strength of the advantages and disadvantages of each approach.

CONCLUSION

Career opportunities for minorities are available in all modes of transportation. In the past these opportunities have been primarily at the entry or low level of the career ladder. As a result of new laws and executive orders, more initiatives have resulted in a number of special programs to train and enhance careers in professional positions within the transportation industry.

The role of the historically black college and university is to train minorities for employment opportunities in the transportation industry. Specialized programs for minorities to accomplish this task have been limited to a handful of programs at these institutions. Because of past initiatives from DOT, these programs have been geared to careers in urban transportation. Because employment trends are directed to careers in freight transportation, which pays higher salaries, there should be a concerted effort to establish more programs in these areas at minority institutions and to recruit more minorities at universities with established transportation programs.

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